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# DEVELOPMENT DIGEST

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of current materials on economic and social development

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currency is expressed in U. S. dollars.)

# FORESTRY



TECHNICIANS CHECK GROWTH OF BRITISH  
HONDURAS PINE IN A FORESTRY RESEARCH  
INSTITUTE PLANTATION, MALAYSIA  
(PHOTO: UNITED NATIONS)

# Tropical Hardwood Trade in the Asia-Pacific Region

Kenji Takeuchi

[ Three countries in Southeast Asia supply most of the tropical hardwood products entering international trade. Methods of encouraging this production for the general development of the producing countries are outlined. ]

## Regional Distribution of Tropical Hardwoods and Their Export

Some 28 percent of the world's land area is occupied by forests, and about two thirds of this forested area consists of hardwood trees. Table 1 gives the distribution by continents of these areas, along with estimates of the distribution of the volume of growing stock obtained by applying estimates of the volume of wood growing per hectare in the hardwood forests of the respective continents. Among the tropical areas: Latin America has over half the world's growing stock of all hardwoods, but in terms of the production and export of tropical hardwood its share is much less than might be expected; Southeast Asia, with less than 13 percent of the world's hardwood growing stock, is the dominant producer and exporter of tropical varieties; Africa occupies an intermediate position as exporter among tropical regions (see Table 2).

Hardwood exports from Africa, mainly to Western Europe, have been growing by about 8 percent annually since the 1950s with an increasing share of the region's output destined for export. The harvesting of

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Table 1: World Distribution of Hardwood Forests

	<u>Areas (million hectares)</u>			<u>Growing stock of Hardwoods</u>	
	<u>Total Land Area</u>	<u>All Forest</u>	<u>Hardwood Forests</u>	<u>billions of cubic meters</u>	<u>%</u>
North America	1,875	700	260	23	9
Central America	272	71	36	3	1
South America	1,760	810	800	152	57
Africa	2,970	680	676	30	11
Europe	471	137	59	5	2
USSR	2,144	728	175	13	5
Asia	2,700	490	400	36	13
Pacific	842	88	84	5	2
World	13,034	3,704	2,490	267	100

Source: S. L. Pringle, UNASYLVA, Vol. 23, 1969 (Table 6).

Table 2: Production and Export of Tropical Hardwoods in 1968  
(millions of cubic meters)

	<u>Production</u>	<u>Exports</u>		
	<u>Logs</u>	<u>Logs</u>	<u>Processed*</u>	<u>Total</u>
Tropical Latin America	16.5	0.4	0.9	1.3
Tropical Africa	12.6	6.0	2.1	8.1
Tropical Asia-Pacific	40.7	20.5	4.0	24.5
Total	69.8	26.9	7.0	33.9

\*Largely sawnwood, sleepers (railroad ties), veneer sheets and plywood.

Source: FAO, Yearbook of Forest Products (annual).

species suitable for industrial use is limited, however, partly by lack of confidence of importers in unfamiliar species and partly by non-accessibility. In some areas, notably Ghana and Nigeria, almost all high forest has already been allocated on concession; but elsewhere improvements in transport facilities could greatly increase output. The Ivory Coast and Gabon are now the leading exporters.

In Latin America, much of the current timber export is of softwoods;

hardwood production and export has been relatively stagnant since the 1950s. Production of the latter is chiefly for domestic use and much of the exports move within the region — e. g. from Paraguay to Argentina. Hardwood production is limited by: a) the extremely mixed composition of tropical forests, coupled with small average size of logs; b) the extremely remote, inaccessible location of the apparently volume-rich forests, notably in Brazil and Peru, leading to high costs of exploitation.

The Asia-Pacific region is the dominant source of hardwood exports, with three Southeast Asian countries — the Philippines, Indonesia, Malaysia — accounting for two thirds of the world total in recent years. Over 70 percent of the logs exported from the "big three" goes to Japan; some of this is re-exported as plywood to the United States, but the bulk of it goes into Japanese consumption. Another 20-25 percent goes to South Korea, Taiwan and Singapore for processing and re-export — chiefly to United States and Japanese markets. Exports have been increasing quite substantially, most notably in Indonesia where they grew sharply from 1.2 million cubic meters in 1968 to over 10 million in 1970, primarily due to the logging boom in Kalimantan (southern Borneo). Compared to Africa or Latin America, the exports of Southeast Asia have a smaller proportion of processed wood, although their absolute magnitudes are larger in both types of export.

#### Prospect for Hardwood Trade In the Asia-Pacific Region

Tropical hardwood resources offer excellent opportunities for the economic development of the Asia-Pacific region. World import demand for tropical hardwood is projected to grow at 6.0 to 6.5 percent per annum (in roundwood equivalent volume) during the 1970s decade. Export earnings from tropical hardwood (including primary processed products as well as logs) of the Philippines, Malaysia, and Indonesia could potentially increase at an average rate of 11 percent to 12 percent per annum during the 1968-1980 period as a result of increased total export volume (in roundwood equivalent), increased average prices of logs, and increased value added due to greater volume of processed wood exports. This estimated growth rate compares with a growth rate of about 4 percent projected for the export earnings of developing countries from all agricultural commodities over the same period. This potential may be realized if these countries recognize their long-run interests and adopt appropriate policies.

Demand, supply and price outlook for tropical hardwood in the Asia-Pacific region. The dominant end markets for the Asia-Pacific region's tropical hardwood are Japan and the United States.

As compared to actual exports of 29.4 cubic meters in 1971, the estimated exportable volume of tropical hardwood of the Philippines, Malaysia, and Indonesia in 1975 and 1985 and the projected import are demand by Japan and the United States for the corresponding years as follows (in millions of cubic meters of unprocessed logs):

	<u>1975</u>	<u>1985</u>
Export capacity of the Philippines, Malaysia, and Indonesia	40.7	43.0
Projected total import requirements of Japan and the United States	39.0	63.0

In addition, the import demand by other countries for the tropical hardwood of the three major southeast Asian suppliers is likely to be about 4 million m<sup>3</sup>(r) in 1975 and substantially larger in 1985. It follows that, in 1975, the Philippine, Malaysian, and Indonesian volume of exportable tropical hardwood will just about meet the needs of their two largest traditional customers as well as those of other smaller customers. It also follows that, by 1985, a large part of the increase in demand for tropical hardwood in Japan and the United States will have to be satisfied by trade flows from new sources because of the limited export capacity of the traditional sources, even if demand by other importing countries does not increase materially between 1975 and 1985.

From the viewpoint of Japan and the United States, the most logical potential sources of additional tropical hardwood would be Papua/New Guinea and Latin America. However, there are two basic problems concerning the forest resources in these areas: they contain a very low volume of timber per unit area (yielding only about one-third the volume per hectare found in a typical forest of the Philippines); and both of these areas have forests of quite diverse species mixture. The processing, handling and marketing problems of such a varied mixture of species are much more difficult than those of the more uniform species mixture in the Philippines, Malaysia, and Indonesia. With the added problem of a lack of infrastructural facilities, the per-unit cost of production of logs in these new areas is likely to be distinctly higher than that in the Southeast Asian producers. Therefore, prices of tropical hardwood logs are likely to move up somewhat through the mid-1970s, and they are bound to rise sharply in the period beyond, barring drastic technological improvements in the production and transportation of tropical hardwood logs that would moderate the high costs of removing massive quantities of logs from forests in Papua/New Guinea and Latin America.

An important implication of the projected long-term rise in the prices of tropical hardwood logs would be that the timber resources

in the Philippines, Malaysia, and Indonesia which are located in the more accessible areas, comparatively rich in per-hectare volume and relatively uniform in species mixture, should command an increasing economic rent over time. In fact, the Philippines, Malaysia, and Indonesia combined have a virtual monopoly of relatively uniform (with respect to species), high density reserves of tropical hardwood. Since the price elasticity of demand for the combined log exports of the three countries does not seem to be high, if these three countries now jointly discourage the expansion of their exports of logs, they could earn more income per unit of logs exported in the immediate future without jeopardizing the total foreign exchange earnings from log exports, while at the same time improving their future prospects for earning foreign exchange from this source.

#### Wood Processing as a Vehicle of Industrial Growth

If all logs that are currently exported in log form were locally processed and then exported in the form of sawnwood, veneer, and plywood, the foreign exchange earnings from forest products in producing countries could be at least two or three times what they are now. From the viewpoint of regional development strategy, primary processing of wood — production of sawnwood, veneers, and plywood — should take place largely in the Philippines, Malaysia, and Indonesia rather than in Japan, Korea, Taiwan, and Singapore. The wood processing industry would accelerate an export-oriented industrial growth of the major log-producing countries. Economic justification for encouraging the growth of their primary wood processing industries rests mainly on the following four points.

1) Primary wood processing activities are typically weight- and volume-losing (hence freight-cost saving) activities. Converting logs to sawnwood, plywood and veneers would lose 40 percent to 60 percent of the volume and weight of log raw material. Ocean freight costs account for about one-fourth to one-third of average c. i. f. prices of tropical hardwood logs imported by Japan and Korea. Since the cost of log raw material accounts for as much as 65 percent to 80 percent of the total cost of producing sawnwood veneers and plywood, the log-producing countries should have a considerable cost advantage in primary wood processing activities over log-importing processing countries.

2) Wood processing activities (excluding pulp and paper production) are relatively labor-intensive activities.

3) Wood processing involves relatively simple technology and skill, while requiring relatively small investments in establishing factories of economic size. The Philippines, Malaysia, and Indonesia

should start with relatively simple products, while Korea, Taiwan, and Singapore should specialize in more advanced products, such as plywoods with chemical finish, various overlays, and printed face, and in secondary processing of furniture components, window frames, and door skins.

4) Wood processing activities could serve as a starter of the industrialization process in the remote areas of the outer islands — Mindanao, Sabah, Sarawak, and Kalimantan — where most of the logs that are currently exported are being produced.

Problems in the growth of processed wood exports. It has been far more profitable for the timber companies operating in the Philippines, Malaysia, and Indonesia to export logs rather than to process the wood first and then export it in processed forms because of: the tariff escalation (high tariff on processed products, low or no tariffs on unprocessed products) in the developed importing countries; the lack of opportunities in the log-producing countries to utilize wood residues economically, which would in effect reduce the cost of production of sawnwood, veneers, and plywood; the difficulties which the wood processing firms in the log-producing countries have been experiencing in obtaining necessary supplies of equipment, parts, and such essential inputs as resins (glues) for plywood production at reasonable costs; the generally low levels of technical skills of available labor in the log-producing countries; and the poor infrastructure in the log-producing countries, especially with respect to internal transportation.

Broadly speaking, tropical hardwood trade in the Asia-Pacific region involves three types of trading parties, that is, the developed importer-consumer countries (Japan, the United States, and others), the developing "in-transit" processor countries (Korea, Taiwan, and Singapore) and the log-producing developing countries (the Philippines, Malaysia, and Indonesia). These three groups of countries have had generally different types of industrial and trade policies. First was the basically "inward-looking" industrial policies of the Philippines and Indonesia; they did not help the growth of exports of processed wood products, but actually tended to penalize the exporters. Second is the decisively "outward-looking" industrial policies of Korea, Taiwan (since the mid-1960s) and Singapore (since independence) which have strongly supported the growth of export-oriented manufacturing. Third is the protectionistic policies of developed importing countries with respect to most "light manufacturing" activities, including wood processing, reflected in the "tariff escalation" of these countries. It is the combination of these different types of industrial and trade policies of the major parties involved that has strongly conditioned the pattern of tropical hardwood trade in the Asia-Pacific region.

A strategy for accelerating the growth of processed wood exports. In recent years the Philippines and Indonesia have changed their industrial and trade policies from being markedly inward-looking to generally outward-looking. To assure a decisive success in their processed wood exports, their outward-looking policies will probably have to be developed even further. Partly due to the early and decisive change of policy in this regard, West Malaysia is now exporting two-thirds of its wood in processed form, mainly sawnwood.

The three major log-exporting countries could encourage wood processing at home by: discouraging the export of logs by jointly maintaining substantial export taxes; encouraging the growth of export-oriented wood processing industries by providing comprehensive "packages" of incentives; adjusting their forestry concession policies so as to discourage exports of logs and encourage exports of processed products; and improving infrastructure to induce rapid growth of export-oriented wood processing industries. In implementing these policies, integrated companies could handle all steps from the resource through processing, shipping, distribution, and even application in end use. Or an integration could be effectively achieved by contractual arrangements, partial integration, and joint ventures. The ideal industrial structure would be one that has deep penetration in a variety of market sectors but is not concentrated enough to exercise monopoly control of the resource and processing industry, and has a vested interest in maximizing processing and species utilization.

Joint actions to discourage log exports would be of mutual benefit to the three log-exporting countries. For instance, if the Philippines and Malaysia alone would restrict log exports but Indonesia would not, then Indonesian logs would fill most, if not all, of the trade volume now moving in log form. The result would be that the newly developing wood processing industries in the Philippines and Malaysia would suffer in competing with the established industries of the traditional log-importing countries. Regional cooperation is clearly in the long-term interest of the countries involved.

Would the exporters of logs not lose in terms of total foreign exchange earnings from that commodity because, although they will get a higher average price per unit, they will be selling less volume than otherwise? Unfortunately, no reliable estimate of the price elasticity of demand for the log exports of these countries is available. However, the demand for tropical hardwood in general is probably price-inelastic because the demand for processed products made from tropical hardwood is generally inelastic. Domestic supply of the closest substitute, temperate hardwood in the importing countries, is quite inelastic; softwoods and nonwood materials are good substitutes only in limited end uses. The cost of getting tropical hard-

wood logs in great quantities from alternative sources such as Indochina, the southwest Pacific islands, and Latin America would be much higher than the existing conditions because of political uncertainties (Indochina), higher freight costs (Latin America), and generally higher cost of production. Competition with Africa in the European market might increase demand elasticity if the African supplies could be increased faster than demand; but this has been a small market for Southeast Asia. Thus, the price elasticity of demand for log exports of the three major Asian exporters is probably less than unity; by acting jointly to discourage log exports, the Philippines, Malaysia, and Indonesia would not lose foreign exchange earnings from logs, while they will have much to gain if the measure contributes toward accelerating their exports of processed products.

It would be advantageous for the three countries to cooperate closely in setting the levels of export taxes, and coordinating national policies on export incentives for processed products and forestry concessions. They can also benefit from consultations on matters of infrastructure involving shipping and stocking. Already, some international cooperation exists among the log-producing countries. In 1969, the Philippines and Indonesia concluded eight agreements on economic and technical cooperation, two of which bear directly upon forestry and forest industries. Through the Association of Southeast Asian Nations (ASEAN), membership in which includes Indonesia, Malaysia, the Philippines, as well as Singapore and Thailand, economic and trade cooperation on timber processing, among others, is being studied.

It should be in the interest of the United States, Japan, and other importers of tropical hardwood, as well as in the interest of the less developed countries, if these developed nations adjusted their policies to anticipate the long-term trends in development of the industry and to facilitate the adjustments needed by a significant reduction of import duties on the processed tropical hardwood coming from less developed countries. In the meantime, Japanese plywood manufacturers should probably specialize in sophisticated products, for example, plywoods with printed face, chemical and other special finishes and various overlays, and products of exceptionally high standards of fire-resistance. They may aim at diversifying themselves vertically, for instance, into the prefabricated housing industry. Finally, the in-transit processor countries — principally Korea, Taiwan, and Singapore — should gradually grow out of the reliance on the export of plain primary processed products. In the cases of Korea and Taiwan, plywood exports are contributing very little in the way of net foreign exchange earnings as a result of excessively generous incentives for export. It seems to be in the long-run interest of these processor countries to move toward specialization in the exports of wood products involving a higher value added and larger net foreign exchange earnings in so-called secondary processing, that is, prefinished plywood, furniture components, and so forth.

## A Long-Term Forestry Policy

World demand for tropical hardwood is expected to continue its rapid growth for at least another decade and, quite possibly, much longer. In the meantime, as a result of the rapid growth of export demand for timber, some of the traditional sources of supply in the region, such as the Philippines and West Malaysia, are being threatened with possible depletion of timber resources in the near future. The experience of the Philippines and, to some extent, that of Sabah and Sarawak, indicates a wasteful use of timber resources due to poor and shortsighted logging practices and a lack of adequate forest management. Indonesia, at the moment, boasts "unlimited" forest resources, but will have to face the problem of depletion eventually and would be well advised to take appropriate measures to avoid wasteful use of its resources as soon as possible, and to maximize the long-run benefits for the nation's economy.

One possibility to alleviate the depletion threats in the forest resources of the Philippines, Malaysia, and Indonesia is fast-growing forest plantations. Man-made forests are growing in importance as sources of industrial wood around the world. Demand for paper and hence for wood material for paper-making is growing fast in the developing countries as well as in the rest of the world. It is highly desirable for developing countries to be able to meet their growing paper needs themselves at competitive costs. Although the hardwoods they do possess in natural forests are increasingly used for pulping, at present the bulk of the grades supplied through the trade are made from long-fiber softwoods. Long-fiber softwoods occur indigenously only in limited quantities and limited areas in the tropical countries. But there are vast areas in the Southeast Asian countries where exotic softwoods and pulpable hardwoods could be grown in man-made forests. The possibilities of forest plantations using a few fast-growing species in the Philippines, Malaysia, and Indonesia should be studied. These plantations could provide additional low-cost wood material for pulp and paper and other forest industries in the three countries in the long run.

[ Extracted from Tropical Hard-Wood Trade in the Asia-Pacific Region, Chapters 1 and 3, World Bank Occasional Papers No. 17, 1974, Copyright ©, International Bank for Reconstruction and Development. ]

## Forestry Management and Investment in the United States

Arthur V. Smyth

[The unique nature of wood as a renewable natural resource and the increasing world demand for wood fiber has encouraged intensive management of American forests. This article describes very briefly some of the advanced forestry management practices of one of the leading timber companies.]

In the early days of the U. S. forest products industry timber was so abundant that it had a relatively low value. Consequently, the resource was used wastefully for many years, and investments in tree planting were not financially rewarding. But as the virgin timber gradually became scarcer, and also more valuable as markets opened up, investments in growing timber became more feasible. In the Southern pine region, a technological breakthrough around 1910 in the kraft pulp and paper industry resulted in the construction of large capital-intensive mills which demanded an assurance of a continuing supply of raw material. The first serious attempts to grow timber commercially began in the South; by the 1920s the last virgin stands of southern pine had been cut. In the far West the old-growth forests on private industrial lands will last another 20 - 25 years. Here, increasing world demand has made intensive forest management practices profitable.

Mr. Smyth is a Vice President of Weyerhaeuser Company, a leading American timber company.

Since World War II there has been a rapid growth in demand for wood products, both in the U. S. and still more in Japan and Europe. The industry is highly competitive, and also extremely cyclical in its price movements, but the overall market trend is strongly upward. This is expected to continue for the many years ahead that are involved in making investment plans for a product with such a long period of gestation. Douglas fir, for example, reach commercial cutting size on a average of 50 years of age -- 40 years in ideal land and growing conditions. To cash in on this booming market, more wood must be grown per acre, and more parts of the tree utilized than before. Research and improved practices are creating great advances in both fields.

The Weyerhaeuser Company utilizes an elaborate computer program for guiding the management of its very large and complex forest investments. The basis of the computer model is tree biology, combined with forestry and processing costs, with an expanding market assumed. The program indicated that forestry management applied to Douglas fir in the western states can be profitable using the following practices. (1) Complete replanting within 12 months after cutting, using 2 - 3 year seedlings from company nurseries. (2) Precommercial thinning after 15 years, removing trees which will be overshadowed and growth-inhibited by taller trees of better quality. (3) Apply nitrogen fertilizer by helicopter, once the non-desired trees are removed. (Ground application to desired trees is too costly in the vast mountainous areas of the U. S., though it may be practical elsewhere.) (4) Commercial thinning. (5) Clear-cutting and replanting after 40 - 50 years, utilizing all the wood possible from each acre; previously almost half the volume of logging was left on the ground as slash. (6) Genetic stock improvement: the Company maintains breeding nurseries for selecting seeds of trees with superior yields of wood. By now, a forest so managed produces 1.9 times per acre the value of an unmanaged forest, and further gains are likely.

(Adapted from a speech to the  
National Economists Club,  
Washington, D. C., November  
6, 1975.)

## Development of Forestry in Chile: The Role of *Pinus Radiata*

Horacio Recart

[The general development of forestry in Chile, and the successful plantation and exploitation of the Monterey pine species, are described.]

Chile has been called a country with a "crazy geography." On the map it appears as a 3,000 mile long but narrow strip of land squeezed between the mountains and the sea, stretching from the hot desert of the north to the cold lands of the extreme south. The natural forests, largely in the rainy middle-south, cover about 13 million hectares; 5 million are considered commercial. In addition, there are about 320,000 hectares of plantations of exotic species, 95 percent of which is Monterey Pine (*Pinus radiata*). When the Spanish conquerors came 400 years ago, a much greater part of the territory probably was covered with forests, but in more recent times, the forests have diminished through lack of adequate protection. Chile has not adopted a definite forest policy nor a proper state administration. The results are too well known: indiscriminate and destructive exploitation, scant utilization of the trees, and heavy burning to clear the land. On the contrary, the government has always given preferential attention to agricultural development, disregarding the principle sustained by foresters and conservationists that no sound agriculture can exist without sound forestry.

Dr. Recart is retired chief, Lumber Division, Corporacion de Fomento de la Produccion, Santiago, Chile.

Six outstanding events have marked the development of Chilean forestry since 1930.

Forest legislation. The forest law of 1931 gave the first impulse to forest plantations. It exempted the land and forest from taxation for a period of 30 years and granted a bonus per hectare planted. A 1951 law offered further incentives, exempting plantations from payment of income taxes and inheritance duties. The 1966 Law of Agrarian Reform stipulates that all plantations established in forest soils cannot be expropriated, no matter what their size might be. This security is vital; 90 percent of plantations and 100 percent of the pine industries are in private ownership.

The Chilean Development Corporation. This government agency, entrusted with the industrial development of the country, decided in 1942 to include forestry in its development programs by creating a special section for the study and preparation of forestry projects. This step meant formal recognition of the importance of forestry in the national economy and the potential value of the forest resources. The Corporation created a line of special credits to foster plantations and expansion of forest industries, and this agency has proved to be a leading, driving force in forestry development.

Study of the forest resources. But the lack of sound resource information was a serious impediment for constructive planning. A technical mission of the U. S. Forest Service, headed by I. T. Haig, came to Chile in 1944. The mission made a physical and economic study, including forest inventory, forest depletion, forest growth, timber requirements, forest industries and forest policy. The information and recommendations of the mission's report have continued to serve as a solid basis and guidance in matters of forest policy and in the planning of development programs.

Assistance in development projects. The principal source of technical assistance in forestry has been the Food and Agriculture Organization of the United Nations (FAO). FAO has undertaken numerous study projects covering practically all fields of forestry and provided a number of technicians. FAO also plays an important role in awakening a forestry conscience, particularly among state authorities, prompting them to take action in forestry matters. Several countries, mainly in Europe and North America, signed agreements with the Chilean government to supply technical advice on specific projects, scholarships, machinery, equipment and other facilities.

Forestry education. Chile for some time recognized that the training of forestry engineers at university level was fundamental for proper management of the forest resources and industries. As

the demand for such professionals increased, the government decided to create a Forestry School at the University of Chile in Santiago in 1952. Two years later a second School of Forestry came to life at the Universidad Austral in the city of Valdivia. The forestry profession is now firmly established in Chile and graduates from both schools are engaged in practically all phases of forestry. The total number of graduate foresters is now around 140 and almost all of them are members of the Chilean Forestry Association, founded in 1960. At the vocational level, two specialized schools have been established: one at the Technical State University in Concepción for the training of technicians in wood machinery and auxiliary equipment; the other for forest rangers, under the University of Concepción in Los Angeles. Both of them are entirely staffed by Chilean personnel.

The Forestry Institute. The Forest Institute was established by the Chilean government in 1962 to carry out applied research in the fields of silviculture, wood technology and economics; to develop forest industries through specific working projects; and to give skilled training to personnel working in forest enterprises by means of short courses, field demonstrations and scholarships.

#### The Role of Monterey Pine

The Monterey Pine, called "Pino Insigne" in Chile, was first introduced in 1886 when the first seeds were imported from the U. S. by a group of landowners in the Concepción area. Their object was to establish plantations for the sole purpose of protecting degraded lands. From the start, the rapid growth and adaptability to poor soils of this new species were surprising. It is estimated that in 1925 there were no less than 5,000 hectares in the provinces of Concepción and Arauco alone. The first formal inventory taken by the Development Corporation in 1952 gave a total of 186,000 hectares. This inventory helped to change the existing attitude toward plantations, making people realize their considerable potential value. A 1970 inventory by the Forestry Institute showed a planted area of 300,741 hectares with a volume of 64,410,000 cubic meters. The total annual yield was estimated in 4 million cubic meters. The yearly planting reached 15,824 hectares during the period 1966-1970.

Lumber. Until 1925 lumber production was confined to the native woods. Around 12 commercial species amply satisfied national requirements, leaving a small excess for export. The first appearance of pine lumber in 1925 found no market, as it was considered of too inferior quality. The first successful marketing of pine was in the form of box shooks for containers; pine proved superior to native woods for this use because of low weight and ease of drying, which facilitated nailing. Gradually *Pinus radiata* won acceptance. In 1940, when total lumber production was 220,000 Mbf (thousand

board feet) pine contributed only 10,000 — less than 5 percent of the total. But in 1970 the picture was quite different: out of a total production of 419,000 Mbf, pine had an output of nearly 234,000 Mbf, or 56 percent. Pinus radiata had surpassed the native woods, boosting production 23 times in 30 years. This spectacular increase may be attributed to the many uses found for pine lumber in rural housing, interior finishing, exterior siding, boxes and furniture. But a great part of the credit goes to better manufacture made possible by modern machinery and equipment for drying and stain treatment. Pine lumber is also gradually finding its way into foreign markets, and in 1970, 56 percent of the total lumber exported was pine.

Pulp and paper. Chile depended in the past almost entirely on foreign sources for pulp and paper. But with the growth of pine plantations, the installation of new plants has given Chile the leadership in pulp manufacture in Latin America. In 1966-1970 pulp production reached 300,400 metric tons per year, leaving a surplus of 96,300 tons for export. The average annual production of newsprint and other papers during the same period reached 242,800 tons, covering the country's consumption and leaving 81,300 tons for export. Thus, in 30 years pulp production has increased 24 times and papers and cardboards over seven times.

Fiber board and particle board. Fiber board did not exist in Chile as a national product until 1959. Before then, the only particle boards produced in the country were of plywood from native woods, and production had remained stationary. There was a real need for a new product, and with Pinus radiata being an excellent raw material and available in appreciable quantities, the fiberboard industry came to life in 1959. The plant started with a production of about 50,000 metric tons per year and in 1970 had reached 16,700 tons. Production during the period 1966-1970 attained 13,000 tons per year. Both types of board are consumed mostly within the country.

The general welfare. Pinus radiata has contributed to the general welfare in employment and regional development. The plantations and tributary industries have opened important sources of permanent employment, permitting the stabilization of the labor force, providing better living conditions in adjacent areas, thus diminishing the traditional migration to urban centers. The application of advanced techniques in the operation of modern machinery, tools and equipment, has opened a wide field for skilled workers and technicians who can be trained through field practice and in the two existing vocational schools. Finally, the plantations and pine industries offer forest engineers attractive opportunities for employment.

Many changes contributing to development of extensive rural

areas tributary to the industrial centers have stemmed from establishment of forest industries. The indispensable structural changes, such as new roads, power lines, communications and auxiliary services, have brought new life to many regions and have signified permanent progress, especially to those distant from urban centers. In the social aspect, the populations established in those areas are usually offered satisfactory living conditions in the form of new houses, shopping facilities, recreation centers, schools, hospitals and other services.

The pine industries represented in 1970 a total investment of nearly \$200,000,000 with an average annual production for the period 1966-1970 amounting to \$106,600,000. Yearly exports during the same period had an export value of \$26,000,000. Pulp and paper represented 85 percent of total investments among the pine industries, 82 percent of total production and 93 percent of total exports. Thus, the role of Pinus radiata in the development of Chilean forestry has been revolutionary. A tree species of little importance in its native habitat, planted in a relatively small area and reaching maturity in 25 years, has created a considerable wealth in a foreign land. The experience of Chile will be, no doubt, of interest to many countries with possibilities of establishing plantations of exotic species. Chile may look to the future with optimism: the country still has 20 million hectares of land waiting to be planted.

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## Tax Incentives for Reforestation

Staff of Extensão Rural

[The devastation of Brazilian forests proceeded unchecked for many years, with no plans for their rational replacement. In 1966 and 1970 the Brazilian government enacted laws permitting deductions in income taxes for investments in forestry projects. In less than five years these tax laws have resulted in 5,228 approved projects for the planting of 1.8 billion trees in an area of over 820,000 hectares.]

Brazil has today 352.3 million hectares of forest land, about 41% of its total territory of which 273.1 million hectares are found in the northern Amazon region. Only 93 million hectares of forest are considered accessible to economical industrial uses, and approximately 40 million are currently being exploited. There are four major types of forest:

1) Equatorial Hygrophytic Forests — These heterogeneous forests, with as many as 100 different varieties of trees in one hectare, are located in the Amazon basin and near the coast line. The amount of timber growing in these forests may be as much as 300 cubic meters per hectare, but only a very small quantity will be of commercial value. The most common species found in these forests are the cedar, caoba, and laurel.

2) Deciduous Forests of Humid Climate — Initially this kind of forest covered extensive areas of

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Brazilian soil in the southern and eastern states and small areas in the northeast and north. But because they occupied regions which were good for agriculture, they were widely eliminated. The remaining forests are now located in small areas; these can yield about 200 or 300 cubic meters of timber per hectare. The most common species found in these forests are the jacarandá (rosewood), peroba, guarantan and cedar: all of these have great commercial value.

3) Xerophytic Forests — These are typical of the dry areas in the Northeast. The trees are of small size, with distorted conformation and the wood is of bad quality. They are used almost exclusively for fire wood.

4) Forests of the Warm-Temperate Climate — These are Brazil's most important forest reserves because they include large areas of pines (*Araucária angustifolia*) located in the southern states. The pine is used as raw material for the production of paper, cardboard, and cellulose.

Until recently these four types of forests were being systematically destroyed. Species of great commercial value located near consumer and export centers were cut down with no concern for replacements. For example, studies by the Ministry of Agriculture revealed that the exploitation of pine reached an annual peak of 250,000 hectares. The same studies concluded that if this rate of exploitation was maintained, it would lead to the total extinction of the species in 10 years. Engineer David Azembuja, a professor at the Federal Rural University of Rio de Janeiro, declared in his work Project for the Development and Research of Forests that the development of Brazilian forests has been limited for many years as a result of three main factors:

1) Lack of species which were economically feasible for the restoration of the forests. Although the fast-growing eucalyptus was found to be the best solution for the demand of timber in many uses, it was evident that one species alone could not entirely satisfy the demand. It was necessary to find new adaptable species which would fill the demands of the various uses of wood which grow day by day with the industrial development of the country. By 1955 the first coniferous trees began to be cultivated in Sao Paulo. They grew fast and were good for many uses. After less than 10 years of cultivation, it was already possible to see that the conifers were a new option for forest restoration. Various different types of the species have already been successfully cultivated: *Pinus elliotti*, *Pinus taeda*, *Pinus caribae*, *Pinus oocarpa*, *Pinus patula*, etc.

2) The small number of forestry specialists in the country contributed to the problem. It was only after the creation of the first forestry school in Brazil in 1960, and the subsequent establishment of other

schools in the same field, that the country had available a larger number of professionals and technicians in forestry. Today 70 forestry specialists graduate every year from four regional forestry schools, and two universities are starting new forestry schools.

3) The lack of economic incentives which would allow the forestry industry to develop its activities on a self-sustaining basis. For many years the lack of economic resources had restricted the development of forestry enterprises in Brazil.

This situation changed after 1964. At that time the government, alerted to the great danger to which our forests were exposed, began to give more attention to the urgent need for action in support of forestry. Studies dating from 1961 had shown that the utilization of timber in Brazil was equivalent to approximately 300 million trees cut down annually, while the restoration of the forests was practically non-existent. To give an estimate of the deficiency in restoration: up to 1966 the total area of forests which had been restored in Brazil did not exceed 600,000 hectares; of these, 400,000 were located in only one state — Sao Paulo.

#### Income Tax Incentives

The Federal government understood that a simple law ordering the restoration of forests and the conservation of the natural resources of the country was not the most practical solution for the problem. Trees would not be planted in sufficient numbers unless the necessary economic support and infrastructure were offered. It was in thinking about these needs that the authorities decided to create a package of income tax incentives with the objective of implementing the country's forestry development.

The first measure tried to stimulate the interest of the rural landowner in the restoration of forests. The new Forestry Code (Law No. 4,771/65) allowed the exemption of rural territorial tax for land used to plant forests for commercial exploration of the timber. Investors were also allowed to deduct from their income tax sums which had been invested in forest renovation projects. Nevertheless, the results were not significant. The government, then looking for more effective solutions to the problem, enacted a series of laws, and devised a new policy of income tax incentives for forestry development projects. The bases for this new policy were Law No. 5,106 in 1966 and Decree Law No. 1,134 in 1970.

The income tax incentives are offered to the taxpayer in two forms. The first, established by Law No. 5,106, allows the taxpayer, either an individual or corporation, to make an investment prior to the time of his income tax return, and he may then deduct from his gross

income those sums which he can prove were invested in forestry development projects, up to 50% of the tax he owes. Law No. 5,106 allows for two types of projects. The "individual project" demands only one participant, who implements the project directly or through a specialized corporation. This kind of project could last for one year or longer, but at least 10,000 trees must be planted to qualify the project for the income tax deduction. Usually paper mills, timber and cellulose industries, and steel industries have taken advantage of this kind of project. The other type of project, known as the "multiple project," is always implemented under the orientation of technical corporations connected with forestry developments. There are now 430 of these corporations registered with the Brazilian Institute for Forestry Development (IBDF).

The second option for income tax deduction, established by Decree Law 1,134 for the exclusive use of corporations, allows the company to earmark 50% of its tax for investment in forestry development projects which have been authorized by the IBDF. It added a new feature to the previously offered incentives in that the taxpayer has the possibility of investing in forestry projects initiated by a third party, while before only the taxpayers who were landowners could take advantage of the incentives. The kind of forestry development projects approved by the IBDF are those which relate to the industrial exploitation of timber, the conservation of soil, or the conservation of water resources. Law No. 1,134 includes two types of participation: in projects with public corporations (of anonymous ownership) the investor participates in the project by buying the corporation's shares. In the other type of project, which are essentially partnerships, the investor receives "participation certificates" in forestry restoration projects.

The decrees regulating the forestry development projects also specify that no project will be approved if it does not include the planting of at least 1% of species which are typical of the area and are economically valuable, or if 10% of the natural forest of that particular area is not preserved. The conservation projects may include different tree species, such as fruit trees or larger species. The areas in which these projects are being developed remain under the supervision of the IBDF in every aspect of their exploitation. The owners of such areas are requested to maintain a register of all the alterations which develop from the exploitation of the forest, including the restoration of the forest, the use of the area for other projects, or the extinction of the forest for natural reasons.

#### Results of the Tax Incentives

The new policy of the government offering tax incentives to the taxpayer has proved its effectiveness. Taxpayers learning that the investment in forestry restoration projects will bring them profits in

a short period of time have answered the government's appeal and invested their money. Statistics compiled by the IBDF reveal that the investment grew steadily. Since August 1967 about 7,100 investors have taken advantage of the new tax law incentives. As of January 1972, 5,228 projects had been approved for the planting of 1.8 billion trees. These trees were planted in an area of over 820,000 hectares, and represented an investment of more than 1.2 billion cruzeiros. Projects are found in 12 states, largely in the southern parts of Brazil. In Sao Paulo 2467 projects have planted 577 million trees, an investment of 400 million cruzeiros; in Paraná, 1097 projects have planted 441 million trees at a cost of 270 million cruzeiros; and Minas Gerais, with 672 projects, has spent 250 million cruzeiros to plant 410 million trees.

### Future Perspectives

The government's attention to the execution of projects which will bring growth to the timber industry are part of its general policy to stimulate the production of commodities in great demand by external markets, such as soybeans, corn, meats, and fish. The forestry projects being implemented now are primarily using the Paraná pine (*Araucária angustifolia*) and the American pine (*Pinus elliotti* or *Pinus taeda*) for reforestation. It is estimated that there will be in the southern part of the country a large production capacity which might permit an annual output of 1.5 million cubic meters of timber by 1975. This amount would be sufficient to manufacture 300,000 tons of the long fiber cellulose — this figure is almost equivalent to 50% of the national production of cellulose for 1970.

Mr. Golfari, FAO's technical advisor working with the IBDF, also estimates that to achieve self sufficiency in the industrial utilization of timber, keeping in mind the increase in population and consumer needs, Brazil will have to restore its forests by a minimum of 2 million hectares. If this objective is achieved, the excellent conditions of soil and climate in the regions where the projects are being developed could guarantee the continuity of timber production. The forests planted with pines and eucalyptus show an annual increase of 20 cubic meters per hectare in Brazil. This figure compares favorably to the United States, where annual production reaches 12 cubic meters per hectare, in France 7.5 cubic meters and in Spain 3.5 cubic meters. The waiting period necessary before the felling of such trees is 7 years in Brazil, while the average period in the United States for commercial trees is 12 years, and in France, Norway and Sweden the waiting period is 25 years.

Besides all these favorable factors, Brazil has large areas which are capable of being used for new projects, thus assuring continuity

for the development of forest restoration. In the southern region alone, from Sao Paulo to Rio Grande do Sul, about 16 million hectares, or 20% of the area, are considered suitable for use in forestry development projects. The lumber production offered by these lands will be sufficient to meet the internal demand and part of the external demand. Regarding external markets we must mention in particular the European market, for which the deficit of timber products will reach an estimated 70 million cubic meters in 1975. Mr. Golfari states that: "Brazil has the potential to supply this demand within a few decades, exporting its excess production of timber obtained from restored forests in products such as chips, cellulose, board, and sawn lumber. Timber products might become the country's largest export in the future."

[ Extracted from "Os Frutos do Reflorestamento," Extensao Rural, Vol. VI, No. 76, April 1972, pp. 3-8. Rio de Janeiro: Associacao Brasileira de Crédito e Assistencia Rural. ]

## Preservation of Species and the Tropical Rain Forest

A. Gómez-Pompa, C. Vázquez-Yanes,  
and S. Guevara

[Indiscriminate cutting of tropical rain forests could in time bring about a permanent loss of tree species now known to be valuable, along with a loss of many species whose qualities have not yet been tested scientifically and whose value might also be considerable. This is due to the very complex mixtures of species found in such forests (e. g. in Malaysia, research revealed 227 species over 4 inches in diameter on only 2.5 acres) and the great variety in local ecosystems.]

During the last few million years of their evolution, the tropical rain forests of the world have produced their own regeneration system through the process of secondary forest succession. This regeneration system evolved in the many clearings that occurred naturally as a result of river floods, storms, and trees that die of age. The genetic pool available for recolonization of these spaces was great, and a number of populations and species with characteristics that were advantageous in the recolonization of such breaks in the continuity of the primary rain forests were selected. These plants were fast growing heliophytes, with seeds which have dormancy and long viability, and efficient dispersal mechanisms. Little is known about their biology, their behavior in the succession, and their evolution. But the few works on the subject point out that there are certain repetitive patterns that can be predicted and that the secondary species involved are fundamentally different from the primary species.

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One of the most important aspects of natural regeneration is that on the floor of the primary rain forest there are always seedlings of young plants of many of the primary tree species. Under the effects of disturbance these seedlings will continue growing at an increased rate, while the secondary species also start growth from dormant seeds in the soil. After several years the primary species will have grown taller than the secondary ones, and the former will take over the upper canopy of the old successional series. Another important means of regeneration comes from seeds in the soil. In tropical rain forests this type of regeneration seems to be very effective mainly for species that happen to be in fruit during the disturbance of the area, because apparently there is a very short dormancy of the seeds of most of the primary species and the entire life of seeds of tropical tree species is in many cases very short.

The many, and quite different primary tree species in the rain forests of the world may behave very differently in their germination responses and life-span. The available evidence indicates, nevertheless, that many primary tree species have large seeds with either short dormancy or none at all. The general trend is toward rapid germination, which is usually advantageous to the survival of the species. If one considers the predators of all types (fungi, bacteria, animals of various types) that are present in tropical warm and humid conditions, it seems reasonable to attribute survival power to species the seeds of which can germinate quickly, and the seedlings of which can remain alive for a long time in a slow-growing condition. Another possibility for the establishment of primary tree species in the early stages of regeneration is by long-distance dispersal by birds and by animals such as monkeys, rodents, and others. This process is playing an important role in areas where human disturbance has not reached a critical level, but very little research has been done on dispersal characteristics. Still another means of reestablishment of primary species in the early stages of succession is vegetative reproduction by means of rhizomes, bulbs, and roots that may remain alive after the destruction of the original forest and become active soon after the disruption.

#### Shifting Cultivation

In addition to regeneration following natural catastrophes, the regenerative system of the rain forest seems also to be well adapted to the activities of primitive man. The use of small pieces of land for agriculture, and their abandonment after the decrease of crop production (shifting agriculture), is similar to the occasional destruction of the forest by natural causes. Shifting agriculture has been a natural way to use the regenerative properties of the rain forest for the benefit of man. After the abandonment of the land by the primitive farmer, regeneration starts with the available seeds and other propagules in the

soil. The seeds now known to remain viable in the soil are mainly those of secondary species, so most of the future propagules of primary trees have to come in by natural dispersal (such as animals, water, gravity, or air). The speed of regeneration under these circumstances is a problem, but in general one can say that under the shifting cultivation system, the genetic pool of primary trees is retained, and from this pool comes the raw material for the successional processes. Of course, this is true only where demographic pressure has not forced an intensive shifting agriculture with only short periods of recovery between cultivations.

#### The Tropical Rain Forest In The Era Of Intensive Cultivation

Permanent use of land in tropical areas now can be accomplished with the help of new technology and chemicals. These methods have opened greater possibilities for making available large extents of land for agricultural crops; the new trends can be seen in almost any tropical area today. Under an intensive and extensive use of the land, sources of seeds of primary tree species for regeneration become less and less available because of the dispersal characteristics of those species, and because of the scarcity of individuals of most of the tree species. The only species available that are preadapted for continuous disturbance are secondary species, or primary species with some of the characteristics of the secondary ones. This group of species has characteristics that enable them to thrive in such conditions; they produce large numbers of seeds, which have means of long-distance dispersal and dormancy; these seeds accumulate and stay alive in the soil (that is, they have a long life-span). The process often called "savannization" of the tropical humid regions can very well be explained by these characteristics; this process may well account for many of the low semi-evergreen selvas and the savanna woodlands in Mexico, as well as similar areas in Asia, Africa and South America. Also, plants preadapted for disturbance, such as ones from drier environments with built-in adaptations to remain alive in a dormant condition for long periods of time, may invade these areas and allow them to regenerate a forest vegetation. An ecosystem consisting of secondary species mixed with species from drier environments will become established. Since these species are generally lower in stature at maturity, the vegetation will also be lower in stature than the one the climate could allow.

#### Implications

With the present rate of destruction of the tropical rain forests throughout the world, there is great danger of mass extinction of thousands of species. This is because primary tree species from

the tropical rain forests are incapable of recolonizing large areas once these have been opened to intensive and extensive agriculture. It has been argued that countries like those of Europe, the United States, and Japan have used the land intensively and extensively, and there is not much evidence of mass disappearance of species. In temperate areas, however, the primary tree species are in many cases represented by a great number of individuals, and the distribution of many of the temperate species is large. In addition, many of them possess seeds adapted to long periods of inactivity, thereby conserving their vitality (dormancy and long life-span) for periods of time while buried in the soil. Even though there are no reliable records of the life-span of seeds of trees buried in the soil of temperate regions, the available data known to us suggest strongly the possibility that seeds stored in soils long retain their potential for growth. All these aspects yield a very different general behavior of the land cleared for agriculture and its possible future regeneration. It is important to note that an isolated tree from a primary temperate forest has greater probability of survival than an isolated tree from a tropical rain forest; this is due to the complex and delicate net of relationships of each individual with that environment. This means that a gene pool of primary trees can be maintained along roads, near houses, and the like, for temperate areas but not for the tropical rain forest. If we add to these ideas the great difference in number of national parks, arboreta, botanic gardens, and storage facilities in many temperate areas, in contrast with the virtual absence of such resources in the tropics, the problem grows to a more critical dimension.

All of the above is applicable to tropical evergreen rain forests in the warm and humid areas of the world. In drier tropical areas with a definite long dry season the problem is very different, and the plants behave in connection with the problems of regeneration under intensive exploitation in a manner more similar to those of temperate areas. The reason for this is that these plants are in some ways preadapted to great disturbances since they possess better characteristics for survival during periods of adverse conditions (drought, fire).

All the evidence available supports the idea that, under present intensive use of the land in tropical rain forest regions, the ecosystems are in danger of a mass extinction of many of their species. This has already happened in several areas of the tropical world, and in the near future it may be of even greater intensity. Thousands of species could disappear before any aspect of their biology has been investigated. This would mean the loss of millions of years of evolution. We urgently suggest that, internationally, massive action be taken to preserve this gigantic pool of germ plasm by the establishment of biological gene pool reserves from the different tropical rain forest environments of the world.

[ Extracted from *Science*, Vol. 177, September 1, 1972, pp. 762-765. Copyright ©, the American Association for the Advancement of Science, Washington, D. C. ]

### Editorial Comment

The above argument for preserving the gene pool of tree species, and especially "primary" species with desirable characteristics, does not constitute a case for not using the resources of tropical forests. Nor does it imply that the extension of agriculture to forested areas should be halted, for it is clear that the feeding of the fast-growing population of the world will require major increases in areas of cultivation on suitable soils in the years ahead. But it does point to the special value of planning small tree sanctuaries in carefully selected tropical areas having representative ecosystems, and beyond that to the urgent need for acceleration of research into all aspects of tropical botany, and for the development and use of appropriate methods of tropical silviculture. Up to now both the basic and applied research in this field have been focused in the temperate zones and on a very limited number of tropical species.

Aside from the establishment of plantations for a few high-valued tropical species like rubber trees or teak, silviculture in the tropics is rarely practiced. Prevalent practices include, on the one hand, the selective cutting of widely dispersed specimens of trees whose high market value justifies the costly method; and on the other, a highly wasteful ignoring of most other species, which are burned or left as slash when land is cleared. A recently inaugurated project in the U. S. Forest Products Laboratory in Madison, Wisconsin has begun to develop methods whereby the extremely heterogeneous mixtures of woods found in tropical forests can be utilized together by reducing them to mixed fibers and reconstituting them into useful products at economic cost: such products include chiefly pulp and paper, but also fiberboard, particleboard, etc. (Up to now, pulp and paper have been produced with processes adapted to particular species.) While research results cannot be described before the work is done, the considerations which caused this project to be supported by the U.S. Agency for International Development indicate good possibilities for a favorable outcome.

To the extent that this use of heterogeneous tropical woods can be accomplished cheaply with widely usable technology, it would have important consequences for tropical countries. It could vastly increase the resource base of a number of countries in Southeast Asia, mid-Africa, Central and northern South America, and add to the supply of paper, housing materials, etc. at reasonable cost — products which are increasingly in demand around the world. At the same time it might accelerate the kind of destructive cutting of forested areas that would have environmental impact, and might also result in greater danger of the loss of tree species noted in the preceding article. Once the commercial exploitation of miscellaneous woods becomes feasible, it will be all the more necessary to proceed

with planned efforts to replant trees, to learn more about characteristics of tropical species and how best to manage such forests, and to establish selected forest reserves. However, the existence of these commercial opportunities should also provide greater financial incentives to invest in research and tropical forest management, incentives which have been relatively weak in the past. As in the American South (see Smyth's article above), the economics of large pulp mills needing a long term assurance of supply are a powerful inducement to the replanting of forests with desirable species.

[ Composed by the editor with the advice of Edward Cliff, Forestry Consultant, Washington, D. C., 1975. ]



Workers at the government nursery at Thaukot, Nepal, put ash tree seedlings in boxes to transplant in reforestation program.  
(Photo: United Nations)

Floating logs and poles on balsa-log rafts down river to Guayaquil, Ecuador

(Photo: FAO)



## The Other Energy Crisis: Firewood

Erik P. Eckholm

[ Firewood is the main source of energy for fuel used by the majority of people today, but in many parts of the world it is becoming harder to find or disappearing with use. Programs for conservation and replanting are urgently needed. ]

The dwindling reserves of petroleum are making headlines; yet for more than a third of the world's people the real energy crisis is a daily scramble to find the wood they need to cook dinner. Their search for wood, once a simple chore, is now a day's labor in some places as forests recede. While chemists devise ever more sophisticated uses for wood, including cellophane and rayon, at least half of all the timber cut in the world still fulfills its original role as fuel for cooking and, in colder regions, a source of warmth. Nine-tenths of the people in most poor countries today depend on firewood as their chief source of fuel. And all too often, the growth in human population is outpacing the growth of new trees — not surprising when the average user burns as much as a ton of firewood a year. The results are soaring wood prices, a growing drain on incomes and physical energies in order to satisfy basic fuel needs, a costly diversion of animal manures to cooking food rather than producing it, and an ecologically disastrous spread of treeless landscapes.

The firewood crisis is probably most acute today in the densely populated Indian subcontinent, and in the semi-arid stretches of central Africa fringing the Sahara Desert. In Latin America, too, scarcity of wood and charcoal is a problem throughout most of the

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Andean region, Central America, and the Caribbean.

### An Economic Burden

The costs of firewood and charcoal are climbing throughout most of Asia, Africa, and Latin America. In Niamey, Niger, the average manual laborer's family now spends nearly one-fourth of its income on firewood. In Ouagadougou, Upper Volta, the portion is 20-30 percent. Those who can't pay so much may send their children, or hike themselves, out into the surrounding countryside to forage — if enough trees are within a reasonable walking distance. Otherwise, they may search about the town for twigs, garbage, or anything burnable. In some Pakistani towns now, people strip bark off the trees that line the streets; thus, meeting today's undeniable needs can impoverish the future. The rural landless poor in parts of India and Pakistan are now facing a new squeeze on their meager incomes. Until now they have generally been able to gather wood for free among the trees scattered through farmlands, but as wood prices in the towns rise, landlords naturally see an advantage in carting available timber into the nearest town to sell rather than giving it to the nearby laborers. While this commercialization of firewood raises the hope that entrepreneurs will see an advantage in planting trees to develop a sustainable, labor-intensive business, so far a depletion of woodlands has been the more common result. Even the essential national forest reserves are not untouched. The gravity of the poaching problem in India has been reflected in the formation of special mobile guard-squads and mobile courts to try captured offenders, but law enforcement measures have little effect in such an untenable situation. Acute firewood scarcity has undermined administrative control even in China, where trees on commune plantations are sometimes surreptitiously uprooted for fuel almost as soon as they are planted.

### Ecological Consequences

The accelerating degradation of woodlands throughout Africa, Asia, and Latin America, caused in part by fuel gathering, is undermining the productivity of the land itself through soil erosion, increasingly severe flooding, creeping deserts, and declining soil fertility. All these problems are accentuated by deforestation, which is spreading as lands are cleared for agriculture and as rising populations continue their search for firewood. Around the Rajasthan Desert in northwest India, overgrazing by cattle, goats and sheep is the chief cause of land degradation, but fuel-wood gathering is also an important contributor to the destruction of trees. Throughout the sub-Saharan fringe of Africa from Senegal to Ethiopia, the caravans that bring in firewood are contributing to the creation of desert-like conditions in a wide band below the desert's edge. Virtually all trees within 70 kilometers of Ouagadougou have been consumed as fuel by the city's inhabitants,

and the circle of land "strip-mined" for firewood — without reclamation — is continually expanding. Similar pressures of overgrazing and deforestation in North Africa are having the same consequences.

In the Indian subcontinent, the most pernicious result of firewood scarcity is perhaps not the destruction of tree cover itself, but the alternative: pyramids of hand-molded dung patties drying in the sun. In many areas these dung cakes have been the only source of fuel for generations, but now, by necessity, their use is spreading further. Between 300 and 400 million tons of wet dung — 60 to 80 million tons when dried — is annually burned for fuel in India alone, robbing farmland of badly needed nutrients and organic matter. The plant nutrients wasted annually in this fashion in India equal more than a third of the country's chemical fertilizer use.

Peasants in the uplands of South Korea have found another, equally destructive way to cope with the timber shortage. A United Nations forestry team visiting the country in the late 1960s found not only live tree-branches, shrubs, seedlings, and grasses being cut for fuel; many hillsides were raked clean of all leaves, litter, and burnable materials. Raking in this fashion, to meet needs for home fuel and farm compost, robs the soil of both a protective cover and organic matter, and the practice was cited by the U.N. experts as "one of the principal causes of soil erosion in Korea." Firewood scarcity similarly impairs productivity in Eastern Nigeria, where the Tiv people have been forced to uproot crop residues after the harvest for use as fuel. Traditionally, the dead stalks and leaves had been left to enrich the soil and hold down erosion.

Rainwater falling on tree-covered land tends to soak into the ground rather than rush off; erosion and flooding are thus reduced, and more water seeps into valuable underground pools and spring sources. But with the loss of tree and plant cover, soil erosion has many adverse consequences. Around the northern and southern edges of the Sahara, the desert is advancing. When tree cover is lost on hill or mountain slopes, the soil is washed away and fertility lost. When soil washes away it must relocate somewhere, and the rising load of silt carried by Asia's rivers is choking up expensive reservoirs behind major dams, and filling irrigation canals. Most threatening of all to food production prospects on the Indian subcontinent, where nearly one in every five human beings lives, is a rise in the frequency and severity of flooding in Pakistan, India, and possibly Bangladesh, the result of denuded watersheds off which rainfall rushes quickly, and of the excessive load of sediment from upstream that builds up river beds, reducing their capacity to channel water.

### A Renewable Resource

The unfortunate truth is that the amount of wood burned in a particular country is almost completely determined by the number of people who need to use it. In the absence of suitable alternative energy sources, future firewood needs in these countries will be determined largely by population growth. The simple arithmetic of exponential growth suggests the immensity of the fuel-wood challenge facing many poor countries. As Table 1 shows, for example, 99 percent of Tanzania's population burns an average of 1.8 tons of wood per person each year. Since Tanzania's population is now just over 15 million, about 27 million tons of wood will be burned for fuel in 1975. But if Tanzania's population should continue growing at the present rate of 2.7 percent annually, it will multiply 14-fold in a century. If the proportion of wood users should remain constant, the consumption of wood for fuel would then reach 370 million tons per year.

Table 1: Fuel Wood Consumption in Tanzania, Gambia, and Thailand

	Fuel Wood Consumption per capita (tons/year)	Fuel Wood as Share of Total Timber Consumption (percent)	Fuel Wood Users as Share of Total Population (percent)
Tanzania	1.8	96	99
Gambia	1.2	94	99
Thailand	1.1	76	97

Source: Adapted from Keith Openshaw, "Wood Fuels the Developing World," New Scientist, Vol. 61, No. 883, January 31, 1974.

Fortunately trees, unlike oil, are a renewable resource when properly managed. People can plant more trees in plantations, on farms, along roads, in shelter belts, and on unused land throughout the rural areas of the poor countries. The concept is simple, but its implementation is not. Governments in nearly all the wood-short countries have had tree-planting programs for some time — for several decades in some cases. But several problems have plagued these programs from the beginning. One is the sheer magnitude of the need for wood, and the scale of the growth in demand. Population growth has swallowed the moderate tree-planting efforts of many countries, rendering their impact almost negligible. Wood-producing programs will have to be undertaken on a far greater scale than most governments presently

conceive if a real dent is to be made in the problem. A second major obstacle to meeting this crisis is the perennial question of political priorities and decision-making time frames. It is hard for any politician to concentrate funds and attention on a problem so diffuse and seemingly long-term in nature. Some ecologists in the poor countries have been warning their governments for decades about the dangers of deforestation and fuel shortages, but tree-planting programs don't win elections.

Most of the regions with too few trees also have too many cattle, sheep, and goats. Where rangelands are badly overgrazed, the leaves of a young sapling present an appetizing temptation to a foraging animal. Even if he keeps careful control of his own livestock, a herdsman may reason that if his animals don't eat the leaves, someone else's will. Marauding livestock are prime destroyers of tree-planting projects throughout the less developed world. Even if a village is internally disciplined enough to defend new trees from its own residents, passing nomads or other wanderers may do them in. To be successful, then, reforestation efforts often require a formidable administrative effort to protect the plants for years — not to mention the monitoring of timber harvesting and replanting activities once the trees reach maturity.

In country after country, the same lesson has been learned: tree-planting programs are most successful when a majority of the local community is deeply involved in planning and implementation, and clearly perceives its self-interest in success. Central or state governments can provide stimulus, technical advice, and financial assistance, but unless community members clearly understand why lands to which they have traditionally had free access for grazing and wood-gathering are being demarcated into a plantation, they are apt to view the project with suspicion or even hostility. With wider community participation, on the other hand, the control of grazing patterns can be built into the program from the beginning, and a motivated community will protect its own project and provide labor at little or no cost. An approach like this — working through village councils, with locally-mobilized labor doing the planting and protection work — is now being tried in India. This approach too has its pitfalls and it may be somewhat utopian. But if it can get underway on a large scale, the fast-growing trees bring visible benefits quickly, and they just could catch on. The Chinese have long used the decentralized, community labor-mobilizing approach to reforestation, apparently with moderate success.

### Alternative Fuels

The wider substitution of other energy sources for wood would, if feasible, contribute greatly to a solution of the firewood problem. In the poor countries the proportion of wood users is falling gradually, especially in the cities, as more residents cook their food with bottled gas or kerosene. Yet events of the last two years have abruptly altered energy-use trends and prospects everywhere. Kerosene, the most feasible substitute for firewood, has now been pulled even farther out of reach of the world's poor than it already was. The hopes of foresters and ecologists for a rapid reduction of pressures on receding woodlands through a stepped-up shift to kerosene withered overnight in December, 1973, when OPEC announced its new oil prices.

Fossil fuels are not the only alternate energy source, and over the long term many of those using firewood will have to turn in other directions. Nothing, for example, would be better than a dirt-cheap device for cooking dinner in the evening with solar energy collected earlier in the day. While some solar cookers are already available, the cost of a family unit, at about \$35-\$50, is prohibitive for many since, in the absence of suitable credit arrangements, the entire price must be available at once. Furthermore, no inexpensive means of storing heat for cloudy days and for evenings has yet been devised.

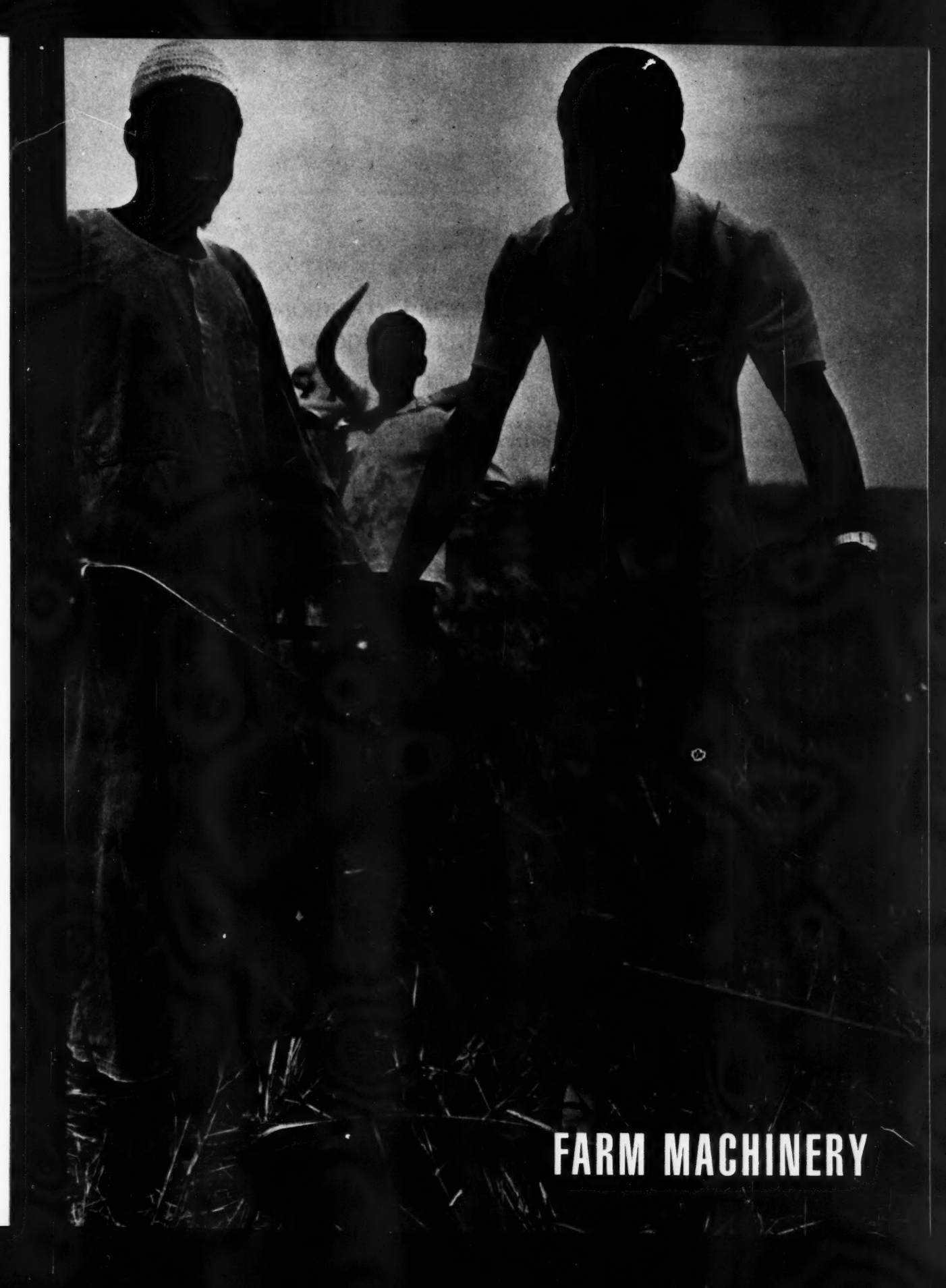
Indian scientists have created a "bio-gas" plant which breaks down manures and other organic wastes into methane gas for cooking and leaves a rich compost for the farm. Over eight thousand of these plants are now being used in India. Without a substantial reduction in cost, however, they will only slowly infiltrate the thousands of rural villages where the fuel problem is growing. Still, it is scientific progress with relatively simple, small-scale devices like solar cookers and bio-gas plants that will likely provide the fuel source of the future in most poor countries.

[ Extracted from The Other Energy Crisis: Firewood, Worldwatch Paper No. 1, September 1975. Copyright ©, Worldwatch Institute, Washington, D. C. ]



Fuel wood for market in  
Nepal

(Photo: FAO)



**FARM MACHINERY**

EXPERT DEMONSTRATES A PLOW IN  
UPPER VOLTA (PHOTO: WORLD BANK)

## The Economics of Farm Mechanization in Developing Countries

Gordon Gemmill and Carl Eicher

[This article supplies an introductory overview of the methods used to analyze the process of mechanization in agriculture, and indicates some of the problems technicians have faced in applying these methods. It includes examples of some of the conclusions of researchers bearing on agricultural efficiency and output, employment, and income distribution.]

Many developing countries face major decisions on how rapidly they should mechanize their agriculture and on the role of the public and private sectors in this process. To ignore such decisions is to make them by default. The decisions are particularly acute since underemployment and unemployment are rising in many such countries. Mechanization involves the substitution of capital for labor, but there may also be a counterbalancing increase in the demand for labor following mechanization due to increases in cultivated acreage and crop intensity. Therefore, a careful empirical analysis is required if the outcome of each alternative policy is to be predicted.

Government has at its disposal an array of policies which affect mechanization. At the one extreme, government may simply allow mechanization to occur at the rate decided by free-market forces and accept the social consequences. At the other extreme, government may be directly involved in controlling the mechanization process. Policies which affect mechanization

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may conveniently be divided into short, medium and long-term categories. We define short-term policies as those directly affecting mechanization, such as subsidized tractor-hire and the inclusion of mechanization in government agricultural projects. Medium-term policies are more indirect and less immediate in their impact: for example, the establishment of a domestic farm machinery industry. Long-term policies take effect over several decades in accordance with some vision of the type of society to be established. Very roughly, short-term policies have a horizon of 0-5 years, medium-term policies of 5-15 years and long-term policies of more than 15 years.

The economic analysis of mechanization policies may be considered at two levels of abstraction. First, there is the more technical question of the amount of change in output, employment and income which will result from each policy. Second, there is the question of who will bear the costs and who receive the benefits, i. e., what will be the result of each policy on the distribution of income, wealth and power in society?

Economists have often condemned rapid mechanization with only a rudimentary (if any) empirical analysis. They have made prescriptions which are clearly normative, such as "all factor-price distortions should be removed" or "mechanization is bad because it displaces labor." As several researchers have shown, the mechanization question is an empirical one which cannot be solved with rules of thumb or cursory analysis. Economists often condemn agricultural engineers for using such rules of thumb as "0.2 h. p. per acre is the minimum acceptable level" or the concept of a "mechanization ladder" as guidelines for policy-making; but the economists are equally guilty of reaching conclusions in the absence of thorough empirical analysis. This ADC/RTN Seminar brought together a group of economists and one engineer, who were currently engaged in research on farm mechanization in developing countries, in order to examine alternative methods of analysis.

#### An Overview of the Mechanization Controversy

Let us define mechanization as any form of power used to assist or replace hand labor in agriculture. This definition therefore includes ox-power as well as tractors, along with the implements to be used with both. The proponents of mechanization have included many agricultural engineers, who have emphasized the technical efficiency of greater mechanization, and the land-owning members of society who view mechanization as a way to increase their own incomes, often via the displacement of tenants. The opponents of rapid mechanization have included most sociologists and economists, who have emphasized both the role of mechanization in creating unemployment and the unequal distribution among rural people of the benefits arising from mechanization. We consider the mechanization of agriculture to be inevitable;

the real questions are how rapidly the process of mechanization should be allowed to occur and what types of machinery are appropriate.

The heart of the controversy is the conflict between goals which occurs in any society. Let us suppose that the government has some stated goals, such as increasing GNP, increasing employment and avoiding a very unequal distribution of income. Let us further suppose that the government has two possible policies in mind: the first is to build a tractor-manufacturing plant and rapidly mechanize agriculture by providing tractors at a price less than the cost of production; the second is to impose very high import duties on tractors and fuel and to encourage the use of ox-power via an agricultural extension service and credit agencies. Assume that the first policy leads to greater output, lower food prices, higher unemployment and a less equal distribution of income than the second policy. Which policy is the "right" one? That depends on the importance of one goal relative to another. Economists and engineers often place different values on these goals, due to their disciplinary orientations, so they give conflicting policy advice.

Let us turn to the data and analyses from which prescriptions are drawn by economists. First, we must decide what sort of data are needed, i. e., what effects mechanization may have; we then need to collect representative data to examine these effects. For example, one may summarize the types of losses and gains which may occur (and therefore need to be measured) when bullock-power is replaced by tractors in a given situation. The most important economic changes concern possible increases in acreage cultivated, increased timeliness and higher yields, changes in crop mixture, costs of machinery and fuel, saving of labor, and saving of land previously used for bullock fodder. Social gains may include an increase in leisure, and social losses may include unemployment and a widening of income differences. Thus, an extremely large number of variables need to be measured in evaluating the impact of a single change in technology on-farm. But the researcher also needs to aggregate over a representative sample of farms and villages if he wishes to reach conclusions on the way in which a certain regional or national level of mechanization would affect society's goals (of GNP, employment and equitable income distribution). In this assessment the researcher also needs to look at possible backward linkages, such as employment in machinery manufacture, and forward linkages, such as lower food prices and hence higher real incomes, leading in turn to increased consumption demand. In the discussion which follows we will look at different approaches to relating the losses and gains in reaching policy prescriptions, giving examples of the kind of results often found when a particular approach is used.

Table 1. Classification of Economic Studies of Farm Mechanization in Less Developed Countries<sup>a</sup>

	Short-term (Static)				Medium-term (Dynamic)			Long-term (Perspective)	
	Cost-Benefit	Cross-Section	Linear Programming	General Equilibrium	Budgeting	Programming	Simulation	Historical	Instrumental
L o c a l	Baldwin [1957] Chancellor [1969] Dalton and Enikwaw [1971] Ellis [1972] b/ Green [1971] b/ Kolawole [1972] Laurent [1968] Lidman [1968] b/ Lord [1963] Peacock [1967] Purvis [1968] Renaut [1966] Van Wersch [1968] Weil [1970] Yudelman [1971]		Ahmad [1972] Clayton [1965] Gotsch [1973-a]						
R e g i o n a l	Chopra [1972] Gemmill [1971]	Donaldson and McInerney [1973] Inukat [1970] Johl [1970] Rao [1972]	Panagides and Ferreira [1970] Vauris [1971]		Singh and Billings [1971]	Singh and Day [1972] Singh and Ahn [1972]		Day [1967]	
C o u n t r y w i d e	Bose and Clark [1969] b/ Kaneda [1969] b/ Timmer [1972-a] b/ Weitz-Hettelsater Engineers [1971]			Thirsk [1972] Sanders [1973]	Johnston, Cowrie and Duff [1970] Johnston and Kilby [1972]		Johnson, et. al. [1971] Rossmiller, et. al. [1972]	Jasny [1936] Kautsky [1900] Marx [1966] Miller [1970] Mesa-Lago [1971] Roberts [1972] Wheelright and McFarlane [1970] Whetham [1970] White [1964]	Gotsch [1972] Schmitz and Seckler [1970]

a/ Readers wishing to fully identify these studies may consult the original of this article.

b/ These cost-benefit studies were economic rather than just financial in nature (see text for explanation).

### Methods of Analysis of Mechanization

A review of the literature reveals that most economic studies of mechanization, while using sophisticated methods of analysis, have relied on very dubious assumptions to compensate for their lack of representative data. Unjustifiably generalized conclusions have been drawn from studies of single mechanization schemes or limited geographical areas. Economic studies of mechanization have usually been the products of lone economists who have not had the resources to analyse a number of alternative technologies and the labor, input (capital) and product markets. Few studies have looked at the effect of population growth on labor supply or have examined the sensitivity

of their results to changes in some key parameters. Table 1 classified some of the most important studies of mechanization according to the type of policy decision (short, medium or long-term) to which the research was, either implicitly or explicitly directed along with the methodologies used.

Cost-benefit analysis. Our chosen study is that of Timmer in 1972 on the choice of milling facilities for rice in Indonesia. An engineering firm completed an appraisal in 1971 and recommended that a small number of large, capital-intensive facilities be established throughout the country. The engineers conducted a financial cost-benefit analysis in which the costs and benefits were valued at current market prices. Timmer completed an economic or social cost-benefit analysis in which he corrected for certain distortions of the market price such as overvalued currency exchange rate. More importantly, Timmer assumed that the real cost of labor was lower than the market-hiring price. His conclusions were in direct contradiction with those of the engineers. The latter recommended equipment costing \$63.2 million and employing 7,300 people while Timmer recommended small power-mills at a cost of \$12.5 million and employing 14,700 people. Timmer's study ably demonstrates the importance of economic rather than merely financial analysis for decision-making.

Cost-benefit analysis is the simplest approach to the appraisal of mechanization. It is very useful, but has generally been confined to a single alternative to the present system, when many alternatives may in fact exist. However, the method can handle multiple alternatives. Timmer was provided by the engineers with a very full report on technical input-output relationships for the five types of rice mill under consideration. Obtaining such data on alternative mechanization options for an entire country can be very expensive. A second shortcoming of many studies has been their concentration on financial rather than economic analysis for policy-making.

Cross section and time series. A second approach to short-term policy research is to conduct a cross-section survey of farmers in an area where several levels of mechanization are in coexistence. Alternatively the researcher may do a "before" and "after" analysis of selected farmers thus constructing a time-series. Donaldson and McInerney (1973) attempted to combine both approaches — cross-section and time-series — in a study of the impact of tractors in Pakistan. They interviewed 208 farmers, located mainly in the Pakistan Punjab, who represented a 3.5 percent random sample of the farmers accepted for World Bank tractor loans. The farmers were questioned about the 1966/67 (before loan) and 1969/70 (after loan) seasons. Only half of the farmers interviewed in 1971 had actually received loans, so the researchers believed that they would

obtain a good comparison of mechanized and nonmechanized farms. Unfortunately, most of the farmers who had not received loans had also mechanized their farms in the intervening period.

The usual approaches to analyzing such surveys are to use chi-squared tests, analysis of variance, and regression analysis. Donaldson and McInerney used chi-squared tests. Their major finding was that, following mechanization, the size of farm operations by owners had grown by 240 percent. This growth was predominantly accomplished by the eviction of tenants, although some land was brought into cultivation and other land was bought or rented. This study gave a very clear indication of the level of tenant eviction which followed mechanization in this area. Several seminar participants had reservations about the sample used and the accuracy of recalled information on such parameters as cropping intensity. Nevertheless, the usual cross-section studies have used even less accurate information and, as a consequence, attributed all observed changes to mechanization.

Linear programming. This approach is best suited to analyzing the impact of mechanization on individual farms; i. e., in a linear programming study one would analyze a small number of farms intensively rather than obtaining a broad overview such as comes from a cross-section survey. Bashir Ahmad conducted a small cross-section survey in Pakistan and then programmed a representative farm which had been extracted from the survey. Running the program with different levels of mechanization gives an indication of changes in output, income and employment following mechanization under various clearly specified conditions. Ahmad's chief finding was that the financial incentive to mechanize with tractors was very great if the farmer had a supplementary supply of water available.

A frequent problem in application of the linear programming approach is its conventional assumption that the farmer maximizes profit, subject to certain defined constraints. Alternative objectives, and especially that of risk-aversion, are not easily incorporated into this method, although it can be done. Nevertheless, it is probably the best tool available for short-term analysis on individual farms, and this accounts for its widespread use in America and Western Europe.

General equilibrium models. Thirsk in Colombia, and Sanders in Brazil, have examined the factors influencing the rate of mechanization for a whole country, using aggregate data. These are "general equilibrium" studies because they begin by assuming that a country's factor and product markets are at a static equilibrium. They then attempt to show what equilibrium would exist under alternative factor and product prices.

Thirsk was interested in discovering whether the Colombian Government's policy of providing credit for mechanization at half the market

rate of interest had increased or decreased GNP and employment, and whether the benefits of mechanization had accrued to (the owners of) land, labor or capital. Using data from a variety of sources, including a national farm management survey and the National Accounts, he estimated the elasticity of substitution between labor and capital in agriculture as approximately 1.4, a figure similar to that in other countries (Sanders found a similar figure in Brazil). He then built a small simultaneous equations model of Colombian agriculture, concluding that the subsidization of mechanization had lowered GNP, favored the capital-owning segment of society, and resulted in lower agricultural employment.

Thirsk's work was analytically very elegant and did show the effect of one government policy. Such aggregate analysis would be a useful complement to micro-studies in moving from short-term into medium-term analysis. However, as Thirsk suggested, institutional questions such as land reform may be of much greater importance in Colombia's development than the question of whether to subsidize mechanization. The analysis did not indicate what should be done next with respect to policies for mechanizing agriculture.

Recursive programming of representative farms. This approach is in the medium-term category, since it is an attempt to simultaneously examine production and investment through time on representative farms. Other possible medium-term approaches listed in Table 1 include simple budgeting through time, such as the work of Johnston, Cownie and Duff (1970), and the simulation approach to agricultural policy evaluation of Rossmiller *et al.* (1972).

At the seminar I. J. Singh discussed his work with recursive linear programming in the study of agricultural development in the Indian Punjab (Singh and Day, 1972). This work was initially intended as a study of the underlying factors in operation as agricultural development occurs. The study treated mechanization as one factor influencing the process of development. The method consists essentially of a series of annual linear programs, the constraints on one year's program being dependent on the results of the previous year's program. Using their model Singh and Day simulated the impact of new technology (including mechanization) in the Punjab for 1952-65 and also made projections to 1980. They predicted that the absolute demand for labor would decline 10 percent between 1970 and 1980 because of mechanization, and this would result in a surplus of labor. The rate of mechanization was shown to be insensitive to small changes in wage and interest rates, hence the potential influence of government policy affecting these factors was severely limited.

Recursive linear programming is undoubtedly a useful approach

to analyzing firm growth over time, but its capacity to make regional projections is questionable: it treats a region as an aggregate having one or a small number of farm types. Changes in the pattern of land ownership, input industries, and the labor market could be incorporated, but the resulting model would be a "monster." Perhaps recursive linear programming could be used for a micro analysis of representative farms in conjunction with a more conventional budgeting approach to macro appraisal.

Long-term instrumental research. These studies are concerned with showing the effects of different institutions on long-term development. An example is the work of Carl Gotsch (1972), who compared the impact of mechanization in Pakistan with that in Bangladesh, concluding that the impact in Pakistan had been less equitable due to the different institutions there. Notably, the distribution of land, capital and power in the two societies was different. In Bangladesh (divisible) tractor-hire had spread the benefits of mechanization, whereas (indivisible) private ownership in Pakistan had led to eviction of tenants. Gotsch believed that economic studies needed to be integrated into a political and social framework if they were to be relevant for decision-making.

In the seminar, Gotsch contended that it was not sufficient to present a decision-maker with some alternative policies. He urged researchers to find ways to actively implement their policy recommendations. The activist should be subtle, however. For example, it would be useless to condemn tractor mechanization when discussing the matter with a Minister if the latter's brother-in-law had a large farm benefiting from rapid mechanization. Gotsch felt that in such a situation the researcher would be wiser to demonstrate to the decision maker the trade-off between personal financial gain and potential social unrest following rapid mechanization and tenant displacement. He suggested that institutional questions had received too little attention. For example, tractor subsidization as a factor-price distortion is approximately equivalent in importance in most countries to agricultural taxation. But land reform is often of far greater importance in combating the spread of socially undesirable mechanization than the removal of either subsidies or taxes.

Gotsch sketched out a block diagram of the general decision-making environment to show how the national regime, government bureaucracy and local power structure each influenced the choice of technology and interacted with each other. He believed that the seminar had concentrated too narrowly on the simple economics of technological choice without concern for the political environment. In some countries, students, the military, and the urban populace might be more important in determining policy than anyone in the agricultural sector. There was disagreement by some participants on Gotsch's definition of the

role of the economist. Some argued that the greatest need at present was for an improvement of farm and regional-level analysis of income, employment and equity following mechanization, feeling that one could not approach the decision-maker until a thorough, basic analysis had been completed. Other participants believed that the economist could make allowance for the political environment by proposing an extreme policy, while really hoping to find acceptance for a more "palatable" second-best policy. To summarize this difference of viewpoint, Gotsch argued for an analysis of the effects of redistribution of property-rights (e. g., land reform) whereas traditional economic analysis takes the distribution of property-rights as given.

Selective mechanization. Mechanization is so country- and commodity-specific that it is impossible to give general policy recommendations. It is also fruitless to discuss "a national mechanization strategy to minimize labor displacement" or "policies to maximize agricultural development while minimizing social conflict." Researchers should recognize that there are trade-offs between goals, and that the most acceptable policy on mechanization will necessarily be a compromise between alternative goals. One type of policy which embodies such a compromise would be selective mechanization to overcome specified seasonal labor bottlenecks without leading to the mechanization of all farm operations.

[ Extracted from Report No. 4 of the Research and Training Network Agricultural Development Council New York, 1973. The seminar described was held at Michigan State University, March 1973.]

Note: This article is intended as an introduction to the kinds of analytical methods used for the subject and some of the problems they often present to policy makers, rather than a discussion of the relative virtues and potentialities of each method per se. Readers may wish to explore the literature cited in the references found in the original of this article, or they may obtain a fuller discussion of the mechanization question by the same authors, free on request, as African Rural Employment Paper No. 4, Department of Agricultural Economics, Michigan State University, East Lansing, Michigan, 48824, U. S. A.

## Village Technology in Tanzania

George MacPherson and Dudley Jackson

[The kinds of technology most useful for agricultural development in Tanzania were explored in a project which examined alternative possibilities ranging from full mechanization to very simple indigenous tools. Reasons for choosing particular implements at different technological levels are analyzed.]

The villages of Tanzania are very poor. The country had a per capita income — including subsistence output — in 1971 of 657 Tanzanian shillings (about US\$92 or £36). In this context, the importance of differences in cost between technologies can hardly be exaggerated. Table 1 provides some illustrative data on the cost of basic farm equipment, comparing the prices of imported tractor-powered equipment with those of ox-powered implements produced in Tanzania. For the items listed, the latter cost only 5.6 percent of the tractor-powered equipment. This differential concerns only the initial capital outlay, and does not take into account the further difference in running costs. Even though the tractorized equipment is more efficient in handling large acreage, and may have important technical advantages, the reality of the farming situation is that such a cost differential puts the mechanized equipment out of reach of the great majority of villages. It therefore becomes important to develop a tool technology that is accessible to subsistence farmers.

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Table 1. Comparative Capital Costs of Mechanized and Intermediate Technology  
(Tanzanian shillings<sup>1</sup>)

Equipment	Mechanized technology (tractor-powered)	Intermediate technology (ox-powered)
Tractor (TMC, 47-hp)	36,800	-
Tractor trailer (UAC, 3-ton)	5,800	-
Four oxen (each sh. 500)	-	2,000
Ox-cart (TAMTU)	-	710
Plough (UAC, TAMTU) <sup>2</sup>	5,610	545
Cultivator (UAC, UFI)	9,000	192
Harrow (UAC, TAMTU)	<u>7,250</u>	<u>175</u>
Total	64,460	3,622

<sup>1</sup>In August 1973 the exchange rate was 6.9 shillings per US dollar.

<sup>2</sup>The UAC tractor-plough is 3-furrow; the TAMTU ox-plough is 2-furrow.

Source: TMC — Tanzania Motor Corporation, price quoted for named model, August 1973; UAC — United Africa Company, quoted prices, August 1973; TAMTU — Tanzania Agricultural Machinery Testing Unit, price list, August 1973; UFI — Ubungo Farm Implements, price list, May 1973.

#### Village Technology Project

With the help of the United Nations Development Programme and two International Labour Office experts and their Tanzanian counterparts, a project was undertaken to study and introduce a program of "intermediate technology" (hereafter referred to as 'the Project'). The task of one expert was to assist in the co-ordination of work among various ministries and other organizations concerned with rural areas,

while the other was to work with TAMTU (Tanzania Agricultural Machinery Testing Unit) on the design and construction of equipment prototypes suitable for village use. For this latter part of the Project it was decided that the work undertaken should conform to the needs the villagers themselves regarded as important. This was largely because previous attempts at introducing "mechanization" had required the constant attendance of government workers such as agricultural engineers, with their relatively sophisticated management of, and accounting for, supplies of fuel and spare parts, regular maintenance, and the proper use of machinery. When the government workers were withdrawn, the machinery tended to fall into disuse for lack of one or a combination of these.

To avoid such failures, innovation should start at the current level of technical competence of the village people. In most villages there are men skilled in the use of the axe, the adze, the panga and the hoe. In many villages there are carpenters who make chairs, tables, beds, doors and houses using these implements, while in some there are smiths who forge adzes, hoes, knives, and other small tools. This provides a reservoir of basic (mostly woodworking) skills which could usefully be tapped by the Project. The use of such village skills enabled the Project to go beyond the stage of intermediate technology implements, as listed in Table 1, to implements of even lower cash cost. Although the capital costs for intermediate technology represent a very considerable saving on those for mechanized technology, the initial cash outlays may still be beyond the reach of a village operating at or near subsistence level. Furthermore, and worse, the implements of intermediate technology are mostly of metal; for construction and repair, they require labor skilled in metalworking and appropriate tools and techniques (e. g. welding). This is beyond the technical capacity of most villages, while the cash to pay for repairs may not be readily available.

It therefore becomes necessary to develop a "village technology" whereby both construction and repair can be undertaken by the villagers. This can be done by substituting wood for metal as far as possible, using materials known to and used by villagers. These include bush poles, tree trunks, planks, nails, bolts and nuts, sheets of corrugated iron, scrap iron from old vehicles, scrap rubber tires and tubes, leather and rope. Many such materials can be obtained, often for only a non-cash labor "cost," and can thus provide a feasible basis for village technology production. For instance, it is not necessary to construct an iron-spoked iron-rimmed wheel, because adequate wheels can be made by cutting two layers of planks (laid at right angles to each other) into a flat circular disc, fitting the disc into an old rubber tire, and then nailing the planks to each other and the tire to the planks. A wooden axle can then be made and fixed rigidly to the wheel. Inserted into wooden bearings containing plenty of grease,

and with reasonable maintenance and the periodic application of more grease, such a wheel and axle function efficiently. In the case of a breakdown, repairs can be made on the spot by the villagers, unlike a metal wheel which may require welding. This type of technology enables the villagers, with the help of a simple and inexpensive tool-kit and their everyday skills, to construct and keep in working order a whole variety of agricultural equipment. Some examples are shown in Table 2.

Material costs are the largest item. Poles are available from various government forestry departments at a charge per foot varying according to thickness and quality; planks can be obtained from timber merchants; bolts, nails, creosote and grease from various shops; while scrap rubber tires can be obtained from garages (a torn tire is a common occurrence on African roads, and is well suited for use in village technology).

Table 2. Village Technology Equipment and Costs  
(in Tanzanian shillings)

Ox-cart		Cultivator	
Materials:		Materials:	
Poles (whole and split)	26.25	Poles	3.51
Planks (bodywork)	67.50	Bolts	21.60
Planks (wheels)	36.00	Wire	0.50
Tyres	25.00	Car springs (tines)	3.00
Bolts	19.80	Total	28.61
Nails	12.00	Labour costs (two man-days)	10.50
Creosote	12.00	Total direct costs	39.11
Grease	3.00	Tool depreciation and amortisation	7.82
Total	201.55	Total direct and indirect costs	46.93
Labour cost (ten man-days)	52.50	Interest charges	4.69
Total direct costs	254.05	Minimum selling price or "unit cost"	51.62
Tool depreciation and amortisation	50.81		
Total direct and indirect costs	304.86		
Interest charges	30.49		
Minimum selling price or "unit cost"	335.35		
		Maize sheller	
Wheelbarrow		Materials:	
Materials:		Poles	3.90
Planks (body and wheel)	22.50	Planks	6.00
Poles	1.50	Bolts and washers	3.60
Tyre	2.00	Nails	3.00
Nails	3.00	Sack	2.00
Creosote	3.00	Wire	3.85
Grease	1.00	Grease	1.15
Total	33.00	Iron	1.00
Labour costs (two man-days)	10.50	Total	24.50
Total direct costs	43.50	Labour costs (three man-days)	15.75
Tool depreciation and amortisation	8.70	Total direct costs	40.25
Total direct and indirect costs	52.20	Tool depreciation and amortisation	8.05
Interest charges	5.22	Total direct and indirect costs	48.30
Minimum selling price or "unit cost"	57.42	Interest charges	4.83
		Minimum selling price or "unit cost"	53.13

Source: Authors' costing

Labor is costed at sh. 5.25 per man-day. The long-term aim of the Project was to establish a "permanent" craftsman in the village who would build and repair equipment for surrounding villages as well as for his own. In this case his food and clothing would have to be provided or paid for by his customers (even within the non-market relations of the Ujamaa village). It therefore seemed advisable to accustom the villagers to the practice of incorporating a labor cost element into their accounting so that the work would be viable on an "economic" basis.

It is also important for the villagers to charge for tool depreciation and amortization. It is most important to accumulate a fund of ready cash for tool replacement against the common event of breakage or wearing out. The rule for such charges has to be simple, and experience showed that a charge of 20 percent on direct costs would generally provide a sufficient contingency fund to keep the tool-kit going. Learning the simple accounting and record-keeping methods to keep track of inventories and tools, and to provide viable costings, is itself a valuable lesson. It provides a basis for the more complex accounting needed for future co-operative activities. Such schemes of accounting and inventory control formed an integral part of the Project. Although it proved difficult to teach even simple accounting to the villagers, a co-operative effort between the craftsmen and the senior members of the village generally solved the problem.

It is very important to the viability of village technology that it should have a flexible cost-structure, because it is possible to substitute cheaper materials for more expensive ones. In the construction of the ox-cart, for example, it is quite easy to substitute split poles for more expensive planks. Split poles require the use of more village labor, but their use lowers the cash outlay considerably. The product resulting from such substitution looks much cruder and may require more maintenance and repairs, but the villagers are not worried by such factors. Their judgements on implements are very pragmatic, and their criteria relate to serviceability rather than to looks. The extra maintenance is also of little concern provided it does not necessitate cash outlays. As compared to the costs of the ox-cart and wheelbarrow shown in Table 2, the cheaper materials described would make it possible to reduce the materials cost for the former by two thirds, and for the latter by one half.

#### Choices among Types of Technology

The cultivator. Labor-time for weeding is one of the notorious bottlenecks in peasant agriculture, and lack of adequate weeding can account for heavy losses in yields. Weeding between rows is traditionally carried out by hoe and requires much arduous labor. But it is technically quite feasible to do the weeding by an animal-powered

Table 3. Comparison of Weeding Costs

	Initial capital outlay	Annual amorti- sation	Annual repairs	Annual cost of man-days per acre	Total annual cost per acre
Tanzanian shillings (round figures)					
Hand hoe	14	3	3	80	86
Village technology cultivator	52	10	26	40	76
Intermediate technology cultivator	192	20	10	40	70

Source: Authors' estimates.

implement called a cultivator. This machine is pulled along between rows of plants with its adjustable blades cutting the weed roots. Hand-weeding can then cope with the few remaining weeds between plants. At a cost of sh. 192, however, the metal cultivator of Ubungo Farm Implements, although an admirable device, is costly for the subsistence farmer. Breakdowns occur occasionally, and repairs or spare parts require a cash outlay at weeding time which is several months before the harvest and therefore a time of cash shortage. The Project therefore designed a cultivator which could be made and repaired in the village. The frame was made of trimmed poles or branches bolted together with simple depth and width controls. The tines, or blades, were made from old car springs, and could be shaped in the village using simple metal working techniques of heating, hammering and cutting. The cultivator was designed to have a low resistance so that one donkey or ox could pull it. The implement was well received by the farmers who were soon able to make their own versions for special needs. At a unit cost of just over sh. 50, with a cash outlay of just under sh. 29 (see Table 3), it represents an appreciable saving on the cash outlay of sh. 192 for the intermediate technology implement.

It is difficult to assess quantitatively the difference in hand-weeding costs and cultivation by either a village technology or an intermediate technology implement, but Table 3 shows the field-worker's best "guestimate." Capital outlay and annual depreciation for the hoe are small but more man-days are needed; about 15 man-days (priced at sh. 5.25 each) would be necessary per acre per annum. With the cultivator the required number of man-days per acre falls to seven per annum, so labor "costs" are about halved, but the

capital outlay rises substantially, especially for the intermediate technology metal implement. The village technology cultivator requires more maintenance, and we have estimated that five man-days per annum would be required for this purpose. However, what matters to the farmer is that this work may be done during a period when the opportunity cost of labor-time is lower. This means that although overall savings are not great, the village technology cultivator breaks a labor bottleneck by permitting more flexible use of labor-time. The metal cultivator might need repair (on average) once every two years, but this would necessitate a trip to town, possibly transporting the cultivator, and cash expenditure for transport, spare parts, and/or repairs. While the village technology cultivator costs notionally more in amortization and repair, it is important to the subsistence farmer that this cost is incurred not in cash but in his own labor-time. The difference in total costs between hand-weeding and the other techniques is not great, but the substitution of "capital" for labor does involve a considerable reduction in labor input and, given the labor bottleneck on weeding, this is a gain of great significance to the farmer. Comparing the two technologies, the difference in the initial outlays is a matter of importance: since both enable the farmer to effect the same saving in man-days required for weeding, the fact that village technology does so for a much lower initial (and cash) outlay makes his preference for it easy to understand.

Ploughing. It is possible to make a village technology plough, but it does not do as good a job as the intermediate technology iron plough, which is well tested and widely marketed in Tanzania, while the unit cost of the two is about the same. Farmers are quick to appreciate all this, and it was therefore explained to them that they should spend what cash they had on a good plough rather than on other implements which could be made more cheaply by village technology. One benefit of village technology is thus to release resources for intermediate technology in cases where the latter is technically superior and the cost difference is slight.

Much the same can be said for maize shelling and grinding. Both these operations can be done by hand or by village, intermediate, or mechanized technology equipment. Intermediate technology shellers save a substantial amount of labor-time as compared with village technology ones; moreover the work for a whole area can be done on a contract basis by one sheller which is thus worked to full capacity and so covers its costs, while the farmer's needs can be suited by paying either in cash or in kind. This costs less than the maize consumed by domestic labor shelling by hand or village technology.

For grinding, the machine hammer-mill of mechanized technology produces a white flour far superior to that ground by hand or the intermediate technology hand-operated plate-mill. The machine mill

costs about 22 times more than the hand-operated mill, but its hourly throughput is 23 times greater; and while its current running costs are higher they are more than compensated by the difference in the quality of the flour and the speed with which it can be milled. This is shown by the spread of contract milling, farmers bringing their grain to the machine mill and paying either in cash or in kind. Contract milling also enables the mechanized technology equipment to be fully utilized and so cover its costs. Thus, there are cases where village or intermediate technology implements cannot compete with those of mechanized technology, just as the village technology plough cannot compete with the intermediate technology one.

[ Extracted from "Village Technology For Rural Development: Agricultural Innovation in Tanzania." International Labour Review, Vol. III, No. 2, February 1975, pp. 102-112. Copyright ©, International Labour Office, Geneva, Switzerland. ]

## Tractors and Ox Plows in Africa

Uma Lele

[ The pros and cons of introducing tractors and associated equipment, as against equipment powered by oxen, are examined in the light of African experiences in rural development projects. ]

One of the frequent solutions to the joint food-labor constraint has been the introduction of mechanical implements to increase the output per unit of labor. These implements vary from simple hand-powered devices to sophisticated engine machinery. The discussion below is focused on the effectiveness of two important mechanized innovations, tractors and ox plows; both are linked to modern multicultivators and weeders, and are frequently introduced through government programs. It illustrates the nature of interactions between mechanization and labor bottlenecks on the one hand, and between mechanization and complementary innovations on the other. It is the inadequate understanding of these interactions which frequently explains the failure of the attempts to mechanize traditional agriculture.

### Tractors

Tractors have often been viewed as a symbol of modern agriculture in Africa and, consequently, have been promoted through many rural development programs. Though tractors have generally proven well adapted to large-scale Western-style commercial farming, their role in development of smallholder agriculture has been less clear for a variety of reasons. First, since the labor bottleneck in peasant farming is largely seasonal, tractor services are needed at only

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the few critical periods of peak labor demand. Second, tractors are most useful in field preparation but often are of little utility in weeding or harvesting. Tractors may, therefore, only postpone rather than break the labor bottleneck while doing little to alleviate the problem of under-utilization of farm labor at periods of slack agricultural activity.

Under some circumstances tractorization has aggravated labor bottlenecks rather than relieving them. For example, mid-season weeding tends to be a highly labor-demanding activity in much of peasant agriculture. When tractors are used for land preparation but not for weeding, as frequently tends to be the case, tractorization increases weeding requirements. This is because tractorization allows expansion of cultivated hectareage and, hence, of the area to be weeded. Since the mid-season weeding period is already a time of peak labor demand, an even tighter labor bottleneck may be created. Similarly, if land is prepared in advance of standard planting dates to make greater use of available tractor time, frequently weed growth becomes well established by the time crops are sown. This, too, creates additional weeding requirements.

Tractorization can, therefore, be successful only if the necessary complementary innovations are introduced to alleviate the labor constraint, especially for weeding. These may take the form of additional capital input — e. g., herbicides or mechanical weeder. Or they may be new planting techniques which reduce weed growth or facilitate weed removal as, for example, the close planting of groundnuts in Operation Arachide or the ridging of cotton in Sukumaland. However, perhaps the most useful step in this regard is to alter cropping patterns to spread the need for labor more evenly through the season. As pointed out earlier, the shortage of labor available to farming activities is largely allocative in nature. New crop mixes and restructured labor patterns can, therefore, provide farmers with the necessary extra labor availability to cope with the possible labor bottlenecks created by tractor use.

Several other problems are frequently encountered in the use of tractors in smallholder farming, including (a) the high capital costs of the equipment and herbicides, (b) the high overhead involved in maintaining and servicing the underutilized machinery, (c) the administrative problems in sharing a limited number of machines among a large number of diverse users, and (d) the technical difficulties of employing tractors under certain topographical and soil conditions.

Of course, none of the above problems is insurmountable. If tractorization is accompanied by substantial increases in productivity, the high capital and recurrent costs of mechanized farming can

be justified. Maintenance problems can be partly alleviated by training local people in proper machine use and repair. Administrative problems as well as the need for scale may be corrected by the introduction of effective group or cooperative farming, or through the use of cooperative or commercial tractor-hire services. And lastly, research can single out the areas most amenable to tractor usages, in addition to providing insights into new ways of adapting mechanization to divergent physical conditions.

Much of the past evidence, however, suggests that successful introduction of tractors is difficult in smallholder agriculture. The experience with mechanized farming in Sukumaland illustrates the problems. In 1964 the Tanzanian government introduced a cotton block scheme which was hinged on the use of centralized tractor facilities. The Sukumaland region seemed suitable for mechanization since much of the land is flat, the growing season is short, and the peak labor requirements are high. Many farmers in the early 1960s were already hiring tractor services. Under the scheme, blocks of between 121.5 and 202.4 hectares were to be cultivated by tractors. Individual plots of 1.62 hectares would then be allocated to farmers for cotton production. The farmers were to raise the crop under close supervision but would retain ultimate responsibility for field maintenance and harvest activities.

The scheme never achieved the scale envisaged. Rather than the proposed ratio of 121.5 hectares per tractor, in the 1964/65 period each tractor worked an average of only 27.1 hectares. The success of the cotton blocks was linked to the assumption that intensive farming on the blocks would lead to an increase in yield per hectare more than sufficient to cover the high cost of the program. Yet, rather than the expected 540 kilograms of cotton per hectare in the 1964/65 period, yields averaged only 180 kilograms per hectare during that period. These yield levels were similar to those achieved by farmers not participating in the program. However, the cost per hectare was approximately six times as high as the cost of production of non-participants. By the end of the cotton block scheme's first season, costs of mechanical cultivation, fertilizer, and spraying (mostly aerial) amounted to TSh. 1.13 million. Only about one-fifth of these expenses were recovered.

The Sukuma experience indicates that careful attention has to be paid to ensure that in practice the increases in production resulting from the introduction of tractors will justify their high cost. Where labor is inexpensive, tractorization may only mean substituting high-cost capital for low-cost labor. Though there often is scope for mechanized input to farming, the introduction of manual or animal-powered equipment may be a more feasible alternative than tractors. The recognition of this fact is reflected in Tanzania's ujamaa policy,

which emphasizes self-reliance among small holders and "less spectacular forms of mechanization" that are consistent with local resources [ see preceding article ].

Despite such a recognition in principle, David J. Vail's study ("Technology for Socialist Development in Tanzania," mimeograph, 1974) notes that in practice the promise of tractor services is frequently used as an inducement for people to form ujamaa villages (a cooperative type of organization promoted by the Tanzanian government). Vail attributes this partly to the identification of tractor use with modernity, by both administrators and policy makers in Tanzania, and partly to the government's desire to promote its ujamaa program rapidly among a sometimes-reluctant rural population. The alternative of fostering intermediate technology of the kind discussed below also seems to be creating a new rural elite of artisans and craftsmen, many of whom seem to use their spare time and the government-provided equipment to produce and service farm implements for private profit. Such a development conflicts with the egalitarian principles underlying ujamaa. Thus, though there may often be strong economic arguments for limiting the introduction of advanced technology such as tractors, compelling political considerations may constrain the use of alternate strategies. Particularly given that several difficulties are encountered in getting production under way in newly formed ujamaa villages, there is a real danger that such political considerations may lead to a repetition of past mistakes with regard to tractorization.

### Ox Plows

The introduction of ox plows to increase labor productivity often seems an attractive alternative to tractorization. Since much of the necessary equipment can be produced and the oxen raised locally, this type of mechanization avoids strain on foreign exchange. The cost of investment in a pair of oxen and a plow is, of course, much lower than that of a tractor. This lessens the need for scale and alleviates the administrative difficulties frequently associated with tractorization. There are also significantly fewer maintenance problems in the case of the ox plows.

However, the use of ox plows faces several of the same difficulties encountered with tractors. The first is the fact that, as with tractor use, ox-plow cultivation may aggravate the seasonal labor bottleneck. Von Rotenhan reports that farmers in Sukumaland using the hoe cultivation devoted about 1,490 hours a year per hectare of cotton, of which 370 hours and 430 hours, respectively, were spent on land preparation and weeding. Farmers using ox-plow cultivation spent about the same amount of time per hectare (i. e., about 1,520 hours). However, among the ox-plow-using farmers, land prepara-

tion accounted for only 120 hours, while labor input for weeding increased to 700 hours. The time saved in the early part of the season as a result of ox plowing was, thus, more than compensated by the increased labor required for weeding later. Because of the heightened weeding bottleneck that may result from using draft animals for field preparation, yields per hectare are sometimes no higher for ox-plow cultivation than for hoe cultivation. The major gain arises from expanded area under cultivation.

Thus, there may be a need, as in the case of tractors, to introduce new crops or crop mixtures that can increase productivity through inserting flexibility in the timing of farm operations. The replacement of broadcast sowing with row planting can also reduce labor bottlenecks. And, of course, there is a wide scope for the employment of low-cost implements that complement ox plows. For example, in the BDPA groundnut scheme in Mali, farmers using traditional methods devote 194 man-days per crop of groundnuts and millet. The introduction of ox-drawn multicultivators and seeders can result in a reduction of fifty man days in the labor time per crop. The additional use of a 100-kilogram ox-drawn cart can result in a further saving of twelve man days. Such an ox cart increases costs of mechanization by only 19 percent. Ox-drawn seeders are another potentially effective complement to ox plows. The Tanzania Agricultural Machinery Testing Unit in Arusha has developed an effective inter-row weeder that can be produced at a cost of \$7 to \$15. This instrument can result in a two-thirds to three-quarters reduction in weeding time for cotton.

Demand for such relatively simple farm implements is frequently substantial in rural areas, particularly when the introduction of such implements is accompanied by other yield-increasing agricultural technologies. In the BDPA groundnut scheme, the number of multicultivators in service increased from 89 to 466 between the 1970/71 period and the 1971/72 period. The number of seeders and carts also increased substantially. Anderson observes that an increasing number of farmers are attempting to obtain several sets of oxen and implements with the goal of expanding their cultivated hectareage. In Tanzania also, as Vail points out, ox plows and seeders are greatly in demand among farmers exposed to the new implements.

The demand for such intermediate technology indicates a strong potential growth linkage between the agricultural sector and the small-industry and service sectors of the rural economy. Promoting use of oxen, plows, weeders, and carts can create employment for craftsmen, mechanics, and cattle producers through the multiplier effects arising from increased agricultural productivity and incomes. However, as noted above, political and other considerations may limit the promotion of intermediate technology and thereby restrict these growth linkages.

The promotion of draft equipment is, however, also limited by its cost, which, though far lower than motorized equipment on a per unit basis, still represents a considerable investment for farmers. Anderson estimates that the average cost of animal traction in the BDPA groundnut scheme is about \$48 per year, including the purchase of the equipment, feed costs, and depreciation. The true costs are probably somewhat higher, since the implements are subsidized, the amortization periods are quite long, and it is assumed that farmers will use young oxen that can be sold as beef cattle for more than their purchase price. Because the maximum projected revenue per hectare of groundnuts for farmers following BDPA-sponsored techniques (early sowing, fungicides, fertilizer, and so forth) is about \$70, the average farmer must grow at least an extra two-thirds of a hectare of groundnuts to cover the cost of the animal-drawn equipment. This should be possible because the equipment allows a reduction of about one-third in the man-days required to cultivate a hectare of groundnuts. However, the revenue figures assume yields of 12 quintals per hectare. In the 1971/72 period average groundnut yields in the BDPA operation were only 8.1 quintals per hectare. At lower yields the economic viability of introducing animal traction becomes progressively more questionable. This is why even an intermediate level of agricultural mechanization and the related rural industrialization frequently cannot be successful without yield-increasing agricultural technologies.

In summary, it seems that both tractorization and ox-plow cultivation have a potential to increase productivity of smallholder agriculture, provided the appropriate associated inputs and innovations are introduced simultaneously. However, in most conditions ox-plow cultivation may be preferable because of its relatively greater flexibility, lower cost, and greater growth linkages with other sectors of the rural economy.

[ Extracted from The Design of Rural Development: Lessons from Africa, pp. 33-38. Baltimore, Md: The Johns Hopkins University Press, 1975, Copyright ©, International Bank for Reconstruction and Development.]

## IRRI Designs of Small Scale Farm Equipment for Developing Country Production

Carol Ulinski and Ann Becker

[The International Rice Research Institute has been designing farm machinery which is adapted to the needs of small rice farmers, and which can be manufactured by small producers in developing countries. In recent years IRRI designs have been produced in increasing numbers in the Philippines, and efforts to encourage production in other countries have begun. The machines and their production problems are described.]

The Agricultural Engineering Department (hereafter referred to as AED), of the International Rice Research Institute (IRRI) in the Philippines, started a program in 1965 to adapt, test and develop more suitable rice-producing equipment for uses in which the available equipment did not perform efficiently. The project first tested the performance of different kinds of equipment currently on the market, with emphasis on the performance of wheels, rotor blades, and spade lugs under flooded soil conditions. The focus was on observing the machines at work; suggestions for modification were directed to engineers of the equipment manufacturers. The AED borrowed equipment from manufacturers and conducted many of the tests at IRRI. During the years 1966 and 1967 representatives from several Japanese, Taiwanese, and American companies, including John Deere and Case, visited the AED at IRRI to obtain some idea of how their respective companies could fill the needs of rice producers.

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In 1967, the directorship of AED was filled by Dr. Amir Khan. Dr. Khan concluded that machinery developed for temperate zones and in industrialized countries could not be adapted to tropical conditions. Khan argued that agricultural equipment must be suited to the social, economic and industrial environment. He attributed the failure of developing countries to absorb foreign technology to the incompatibility of the technology with local environmental conditions. Second, he stressed the relationship between the design and manufacture of a product. He had found a lack of designs for simple machinery which could be produced with indigenous resources. The product design largely determines the production process; the failure of the development of a labor-intensive farm equipment industry in developing countries is largely due to the absence of appropriate designs.

Under his leadership, the revised objectives of the project are two-fold: 1) to develop agricultural machines which are economically suitable to small farms, ranging from 2 to 10 hectares in size (according to Khan, the farmer with a holding smaller than 2 hectares does not have the resources for investment in agricultural machinery); and 2) to design equipment which can be produced with locally available resources of developing countries. Initial program strategy included the following: (1) a survey of small Philippine rice farms to determine their equipment/machinery needs; (2) a survey of small Philippine industrial firms to appraise their production capabilities; and (3) a survey of part shops to determine which components were readily available. With these findings in hand, IRRI engineers set out to design machinery appropriate to the needs of the farmer and also to local producer capabilities and resources.

#### Surveys of Farmers and Manufacturers

A sample survey of rice farmers in Central Luzon during 1966-67 indicated that the size of the average farm operation is 3 hectares. The typical farmer plants one crop per year and is dependent upon the monsoons to satisfy his requirements for water. His primary power source is a water buffalo, which he uses in conjunction with a few simple implements such as harrows and plows (only one of the 114 farmers questioned owned a tractor). In all cases the source of power — be it water buffalo or tractor — is used only during the land preparation stage of the farming cycle.

<u>Size of Holding</u>	<u>Power source &amp; equipment</u>
less than 1.5 ha.	1 plow, 1 harrow, 1 water buffalo
1.6 - 3.5 ha.	1.4 plows, 1.5 harrows, 1.5 water buffalo
3.6 ha. and more	2 plows, 2 harrows, 2 water buffalo

Requirements for labor are greatest during the following periods: land preparation, transplanting, and harvesting/threshing. Labor is readily obtainable for transplanting and harvesting as the work can easily be done by women and children. Shortages arise during land preparation, which is much more strenuous and can only be performed by men. In 1966-67 when the survey was conducted, the task of weeding did not require much labor; but IRRI specialists predicted that, as more and more farmers began planting the new high yielding rice varieties needing more intensive care, labor shortages might become a constraint in this area as well.

The AED also compiled data in several surveys on those farmers who had chosen to invest in hand tractors. Their holdings were not substantially larger than those noted above, but almost all the hand tractors belonged to farmers whose land was irrigated and who planted more than one crop each year. This is in striking contrast to the typical farmer relying on work animals for power, whose farm is dependent on rainfall and who plants only one crop per annum. A frequently expressed reason for mechanizing was time saving: preparation of land can be accomplished more quickly with a hand tractor, leaving more time for other work or for leisure, according to the farmer's taste. Also, unlike work animals which require rest periods, tractors can work throughout the day; and tractors only consume fuel while they are being used, whereas work animals must be fed daily the year round. In a 1971/72 survey, 60% of the farmer sample cited the nuisance involved in caring for an animal and the fear of theft or poisoning as the major determining factor in the decision to mechanize. But a later survey indicated that farmers were more likely to keep their water buffalo than sell them after buying a tiller.

The major problems of mechanization, according to the farmers interviewed, were: (1) the initial difficulty in obtaining a tractor, including cost and access to credit; and (2) the high prices of spare parts. Subsequent studies identified other reasons why farmers have chosen not to mechanize. A number of farmers, for example, noted that the tractors available on the market were not efficient because they bog down in the mud. Some 70-85% of the farms are tenant-operated; and the usual arrangements for the sharing of costs and returns between tenants and landlords, particularly for land preparation where the tenant pays the entire cost, had often made ownership of the machinery available up to then an uncertain and unattractive investment.

Profile of small-scale industry. According to the definition used by the AED, a firm is small-scale if it employs 4-20 people and the value of capital per employee does not exceed P4000 (The Philippine peso value is P7 = \$1). These firms are on the whole more labor intensive than larger ones. Small industry accounts for 78% of firms in the Philippines but only 6% of all industrial income. These firms

employ 18.4% of the manufacturing labor force, and their employees are paid on average about half as much as their counterparts in large companies. About 80% of the companies classified as small-scale are located outside of the Greater Manila area, in contrast to the larger ones which are concentrated around the capital.

The AED also undertook to identify some of the problems faced by small firms. A study of a typical single proprietorship firm, for example, in which the owner-manager is also its only engineer and designer, indicated that when the company expanded its activities the major problem became one of management. The firm had reached a size in its development which required diversification in management beyond the capabilities of a single individual. A second major problem for small firms is the lack of adequate marketing access. Many of these companies have no direct outlets for their goods and consequently produce only on special order. A third problem stems from the paucity of commercially viable products which can be competitively manufactured by the small, labor-intensive firm. For this reason some of them showed an avid interest in the design and development activities underway at the AED.

#### New Equipment Designs

One of the first pieces of equipment to be developed by the AED was a thresher. In the industrial countries the advent of the combine harvester eliminated the need for a thresher, and many companies no longer manufacture them. But the combine harvester has found little acceptance in the developing countries for a number of reasons, and the thresher is very much in demand. The AED commenced work on two models: a drum-type power thresher, and a table-type power thresher. The first designs of the drum-type power thresher were released to industry in 1968, and it was not commercially profitable. The table-type thresher, despite its lower production costs and simpler design, was also unsuccessful commercially. Farmers appeared to be disinterested in the hold-on type nature of both threshers, and wanted a machine with greater capacity. Consequently, IRRI engineers developed a third model — the axial floor thresher — which is the throw-in type and has four times the capacity of its predecessors. This last model is currently being produced by local firms and has been relatively popular.

Other machines designed and developed at IRRI include a seeder which can sow pregerminated rice on puddled soil, a power grain cleaner and a mechanical weeder. The weeder is in direct response to the high yielding varieties which require intensive care. The most important design, in terms of commercial acceptability, is the 4-6 hp (horsepower) tiller which was released to manufacturers in 1972.

The tiller. A comparative cost analysis of alternative power sources for rice production indicates that the most economical method for land preparation in the Philippines varies with the size of the farm. On holdings from 4 to 50 hectares, hand tractors (i. e. tillers) are the least costly method. Work animals are most economical on holdings smaller than 4 hectares; whereas four-wheel tractors become viable on holdings larger than 50 hectares. A survey in Laguna Province revealed that hand tractors are used on farms which average 4.5 hectares in size.

Until the AED designed a tiller for local production, the majority of hand tractors were imported. Most were imported from Japan in completely knocked down form and assembled in the Philippines. The Japanese models were expensive in the 1960s, and the devaluation of the peso in 1970 plus later revaluations of the yen substantially increased the prices of such imports. Local manufacture of the Japanese tiller within the Philippines is not practical because these machines are basically designed for capital-intensive, mass production techniques unsuited to the capabilities of the majority of Philippine companies. The AED, familiar with the success of Thai engineers in developing designs of agricultural equipment which could be produced in domestic small machine shops, set out to develop a small lightweight tiller.

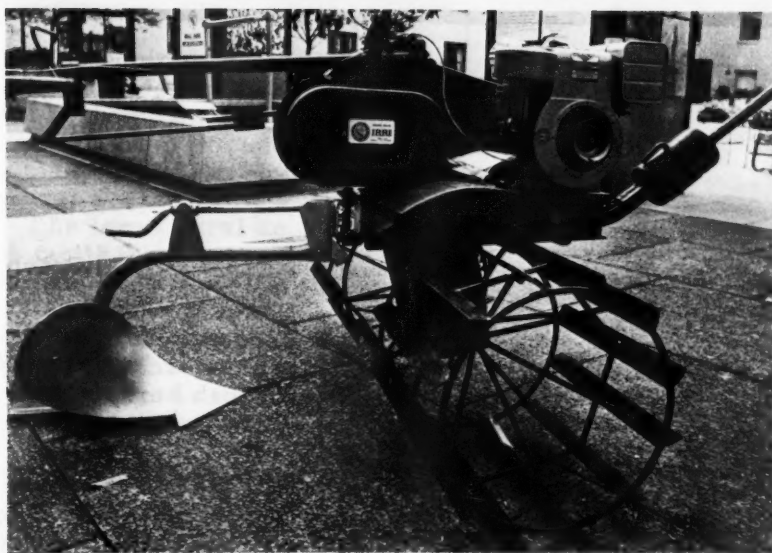
In designing the tiller, engineers had to pay particular attention to three factors. 1) The tiller must be light enough for 2 or 3 men to lift if it should bog down in mud. 2) It must be simple, so that farmers can understand how it works and local job shops can produce it with local resources. 3) An important consideration is cost: the tiller must be cheaper than imports.

The 4-6 hp tiller meets these criteria, and is without a doubt one of the most successful machines developed at IRRI. The local content of the tiller ranges from 50 to 80 percent, with the following components imported: engine, roller chains, sprockets, bearings and seals. It is relatively light (112 kg), of sturdy construction, and can perform a number of operations including plowing, puddling, cultivation and hauling. Operation and maintenance costs are low. Repairs can be done quickly and cheaply with locally available components. And it is inexpensive: the Philippine model can be purchased for P4,000 whereas the Japanese tiller, with the same performance specifications, sells for P7,000 (February 1973 prices).

A survey conducted in early 1972 indicated that somewhat larger imported tillers in the 8-14 hp range had become very popular among Philippine farmers. This demand for a more powerful product, coupled with widespread acceptance of the 4-6 hp tiller, inspired Marsteel Co. to put a larger motor into the small IRRI tiller, priced at P6200, which sells quite well. (This price compares with P28,000 for the Japanese

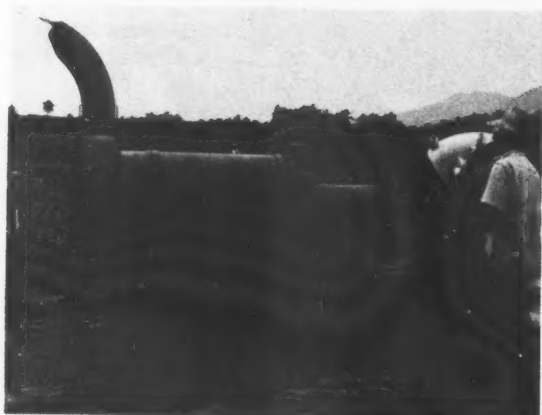


## IRRI Power Tiller





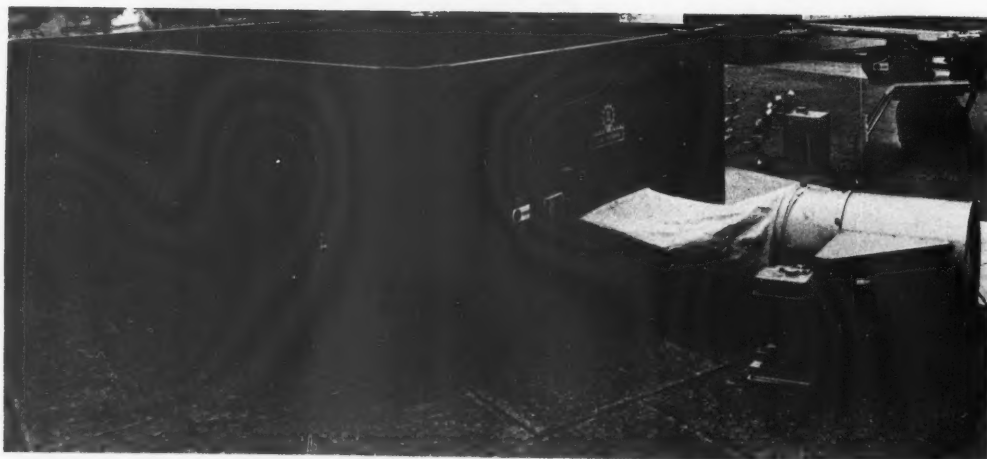
## IRRI Thresher



LEFT: Another type of  
thresher

BELOW: IRRI Batch Dryer.

Grain is placed on screen  
across middle dryer and motor  
pushes air underneath and up  
through kernels.



equivalent; foreign exchange is about one third the cost of the former, one half that of the latter.) IRRI engineers then began to develop a slightly larger 8 hp model. These designs have been released to five Philippine companies, and prototypes should be available for testing by IRRI engineers sometime in 1975.

AED has recently initiated work on the development of a small riding tractor (15-20 hp) which is tailored specifically for medium-sized farmers and small custom operators. The majority of riding tractors produced in the industrialized countries are very expensive, and their heavy weight makes them unsuitable for wetland conditions. The AED engineers are designing a tractor which is light enough for wetland conditions but which, with the addition of weights, can also be used for dryland operations. IRRI is testing this concept on an Economy tractor, which has desirable features of lightness and high clearance. This American tractor has been adapted to local conditions, and preliminary tests indicate that the new model has good mobility under wetland conditions.

Processing equipment. Increasing attention is being directed by AED to post-harvest operations such as drying and processing. The traditional system cannot adequately handle the increases in productivity resulting from the adoption of the new seed-fertilizer technology. In many of the developing countries where most of the population lives in rural areas, some 50-70% of the rice never enters an urban market. The large rural consumption of rice, and the lack of adequate transport facilities in the rural areas, indicate a need for intermediate-scale drying and processing systems for village operations.

The Japanese manufacture a batch dryer, but its cost is prohibitive for the typical Asian farmer. Another disadvantage of the Japanese dryer is that it is mass produced and therefore is not suitable to production capabilities within the Philippines. The criteria for the batch dryer are similar to those for other IRRI-designed equipment: it must be designed so that it can be manufactured with simple production methods and indigenous resources, with minimum reliance on imported components. It is hoped that the IRRI model now being developed will cost less than half that of the most sophisticated Japanese product.

#### The Manufacture of IRRI Designs

Contacts with industry in the industrialized countries. A Japanese company was the first to successfully produce and market an IRRI design. On a visit to the Philippines, Mr. Ohtake of Ohtake Agricultural Machinery Company Limited was exposed to and became interested in the power paddy weeder. He returned to Japan with copies of the design, which he obtained at no cost, and developed a mini-cultivator.

The machine has enjoyed a high degree of commercial success in Japan.

IRRI policy is to distribute its designs at no cost to all interested manufacturers in both industrialized and developing countries. To date, no firm has been granted exclusive rights to any IRRI-developed design. An Australian company — the National Springs Pty. Ltd. — became interested in manufacturing the IRRI thresher for export to Asian countries, and requested exclusive rights to production. The request was refused, and the company apparently found it too risky to produce an unprotected technology. Ohtake, on the other hand, has taken the risk and its mini-cultivator has proved to be extremely profitable (and it has obtained a number of patents on changes it has made in the original IRRI design — unlike any of the Philippine companies which are required to report any changes to IRRI under the standard IRRI contract, Ohtake had signed no written agreement with IRRI). The IRRI grain cleaner sparked the interest of both an American and a Japanese company, but neither has yet begun production. Two Japanese firms, however, have recently started to produce IRRI weeders.

Except for the few cases mentioned, however, such industry involvement has been minimal. The incentives to manufacture and market simple equipment for a foreign market do not appear to exist. The only justification for large companies in the industrialized countries to produce this type of equipment would be to secure a place in some market in anticipation of future market growth. To date, no firms in any Western countries are producing the IRRI designs, and there doesn't appear to be any sign of interest in catering to the small, tropical rice producer. In Japan, however, the domestic farmers' needs are closer to those in countries like the Philippines.

Production in the Philippines. Substantial efforts have been made by IRRI to introduce its designs to industry in the Philippines. In 1971 IRRI launched an extensive advertising campaign in an attempt to interest local producers. Even though the designs were being offered free of charge, few firms showed any interest in manufacturing the machines at that time. Disinterest may perhaps be attributed to a lack of risk capital and government incentives. IRRI then contracted with a number of firms to build prototypes. In 1973 the government raised its tariff from 10% to 30% on imported power tillers and tractor attachments (but not on four-wheel tractors) to encourage local industry. In the last few years production from IRRI designs has spread rapidly; by June 1975 some 20,000 IRRI machines had been produced, the most popular models being power tillers, threshers and weeders.

Procedures for releasing the IRRI designs to manufacturers follow a readily identifiable pattern. When R&D on a design has been completed, drawings and a bill of materials are released to manufacturers who have expressed an interest in the machine in question. Each

submits a cost estimate for the production of a prototype, and IRRI selects a few manufacturers to perform the job, basing its choice on the cost estimates and on the firm's production facilities. More than one firm is chosen in order to encourage competition and hence "cost-consciousness" on the part of the manufacturer. Upon its completion, the prototype is shipped to IRRI where its performance is tested and evaluated. It is then returned to the manufacturer with suggestions for improvements. At this point the manufacturer must decide for himself if he wants to commercially exploit the technology. From here on in he is on his own. Although IRRI will provide engineering assistance when problems arise, IRRI cannot assist the actual marketing of the product.

After a firm makes the decision to manufacture an IRRI-developed design, a number of problems must be successfully tackled before the product reaches the ultimate consumer. These include the following: keeping a lid on production costs, pricing an unprotected technology, and marketing the finished product.

A firm in a developing country experiences great difficulty in keeping production costs low. Because the metals industry in the Philippines is relatively undeveloped, local firms must rely on expensive imports to fulfill their needs for raw materials. Purchases of materials and components are financed by short-term credit, frequently obtained at very high rates of interest. These costs are partially offset by the availability of cheap labor and by the simplicity of the IRRI design: for example, cost reductions have been made possible by reducing the number of moving parts. However, production costs remain sufficiently high to be a matter of general concern.

The firm is faced with several problems when the time comes to put a price tag on the finished product. The selling price must cover production costs and profit while remaining competitive with similar equipment manufactured by other firms who may also obtain IRRI designs at no cost. A second difficulty in pricing IRRI-designed equipment is related to the nature of the market. The machinery in question has been tailored specifically for small farmers whose resources are limited. For them, the purchase of an IRRI machine represents a major investment, and manufacturers must be sensitive to the pocketbooks of the potential consumer so as not to price him out of the market.

The existence of a reliable marketing system may be critical to the commercial sales of a new product. The larger factory's physical location may be far removed from the actual market. The distributor, either in the form of a company branch or a dealership, bridges the gap between the factory and the consumer. In this respect, the larger companies have a distinct advantage over the smaller firms and local job shops, as the latter often lack a sales organization and

sell only to local farmers. In the case of the IRRI-designed equipment, experience has shown that it is desirable to introduce new machines through manufacturers who are well established and have their own sales organization. Custom fabrication shops may be effective in building made-to-order machines but generally do not have the necessary organization to effectively develop the potential for a new machine.

The importance of a marketing system is well illustrated by the case of Marsteel, the largest manufacturer of IRRI designs in the country. It has been suggested that the IRRI machines gained popularity in the Philippines only after this firm started producing the 4-6 hp tiller and marketing it through the 40 established Marsteel outlets throughout the country. A spin-off effect of this tiller's success was to generate interest in it among small firms and job shops. The Marsteel-produced power tiller has become, unintentionally, an excellent form of advertising: it has permitted small manufacturers throughout the country to become acquainted with the designs, and to discover for themselves that the technology can be produced cheaply with available capital resources. Luis Bernas, Marketing Manager of Marsteel, informed us that his company is actually encouraging small firms to enter the market. According to Bernas, proliferation of small firms manufacturing agricultural equipment is a low-cost, effective method for developing the market for said products. Once the market has been developed the battle will be to capture the largest possible share of total sales. Bernas hinted that when the time is ripe, Marsteel could temporarily lower product prices, driving out smaller competitors who are unable to respond in like fashion.

Survey of producing firms. In a 1975 survey by the authors of local agricultural equipment manufacturers, producers of both IRRI-designed and independently designed equipment were interviewed. A total of thirteen firms were canvassed, eight in central Luzon near Manila and IRRI, and five to the south on Mindanao island. All eight firms in the north are currently producing or have produced IRRI-designed equipment. Seven firms are fabricating the axial flow thresher; three are manufacturing the power tiller. The batch dryer is produced by 2 firms, as is the plant seeder. Four of the firms have independently designed equipment for which they have obtained patents.

None of the five firms canvassed in Mindanao are currently manufacturing IRRI equipment although one firm had built a prototype of the IRRI power tiller, and two firms stated their intention to commence production in the near future. One entrepreneur in Davao has sold forty-seven units of a power tiller he himself designed. Four of the five firms are fabricating threshers which were designed by a native of Cotabato in the 1950s. In terms of sales, the power tiller has gained wide acceptance in central Luzon but is seldom seen in Mindanao. The small thresher, on the other hand, is popular in Mindanao but has received little acceptance in the north.

Eleven of the thirteen firms we surveyed can be classified as small-scale, with 4 to 32 employees. The two larger firms employ 150 and 1500 workers. The production facilities of most firms are relatively simple. In most cases the most expensive, sophisticated machine tool is the lathe; the majority of the work is accomplished with benders, grinders, selders, and drills. The one exception is Marsteel, which has facilities for molding, casting and forging. All producers have made some changes in the original designs, but Marsteel has extensively redesigned the IRRI tiller so that it can be fabricated with automated production facilities. However, it is only producing a few units of the thresher, which involves a more labor intensive process and is therefore too costly for the company's existing production facilities at the current level of demand.

### Trends

There has been a strongly increasing demand for agricultural equipment in the Philippines during the past 7 years which can be attributed to the government's irrigation program, to the widespread adoption of high yielding varieties, and the shift toward more intensive cultivation of land. The country still relies heavily on imports to satisfy its requirements for farm machinery. However, local production more than tripled, and its share in total consumption doubled, in the period 1969-1973, increasing from 16% to 33%.

Table 1: Philippine Consumption of Farm Machinery and Equipment  
(in thousand pesos)

Year	Local Production		Importation		Total	
	Value	%Share	Value	%Share	Value	%Increase
1969	22,820	16	115,500	84	138,320	--
1970	39,350	23	131,730	77	171,080	24
1971	66,920	26	186,610	74	253,530	48
1972	58,450	22	206,160	78	264,610	4
1973	70,810	33	144,740	67	215,550	-19

A look at the structure of production costs for the past six years indicates that raw material expenses have grown sharply relative to labor costs. In 1968, 53.6% of manufacturing costs could be attributed to purchases of materials. This had moved up to 71% in 1973, due in part to increased prices of imports after the peso de-

valuation. Direct labor costs declined over the same period from 24% of total cost in 1968 to 12.4% in 1973. Manufacturing overhead also declined, from 23.8% in 1968 to 16.6% in 1973.

Ancillary industries within the Philippines remain relatively underdeveloped, however, Only the larger, more capital-intensive firms have facilities for castings and forgings. Supplies of local machine tools are also limited; a creative owner/operator may produce his own lathe, but the majority of the more sophisticated equipment is imported. The Philippines does have a capacity for steel production, but the quality of local steel is questionable.

Four wheel tractors. In 1973 the tractor population in the Philippines was estimated to be 14,000. The country does not have the capability to produce this equipment locally and is completely dependent on foreign sources. The most popular brand is the Ford tractor which accounted for 50% of total sales in 1973. Local content of the Ford tractor is minimal, averaging only about 1-2%. Tractor implements such as plows and harrows have a local content of 20%.

At the present time 47% of the tractors are used in the production of rice and 41% sugar cane. These statistics are useful when predicting future demand for tractors in the Philippines. D. N. Porter, for example, predicts slow growth in the near future, estimating that total annual sales will reach 1,500 - 2,000. This phenomenon can be explained by three factors. First, the needs of the sugar cane industry for tractors have been almost completely satisfied, and future demand, excepting replacements, will probably be limited. Second, the number of large rice farms — over 15 ha. — will decline as a result of Land Reform, and more farmers will opt for the less expensive power tiller. Third, demand for tractors by corn producers will probably be limited, due to the small size of most corn farms which makes tractor ownership uneconomical.

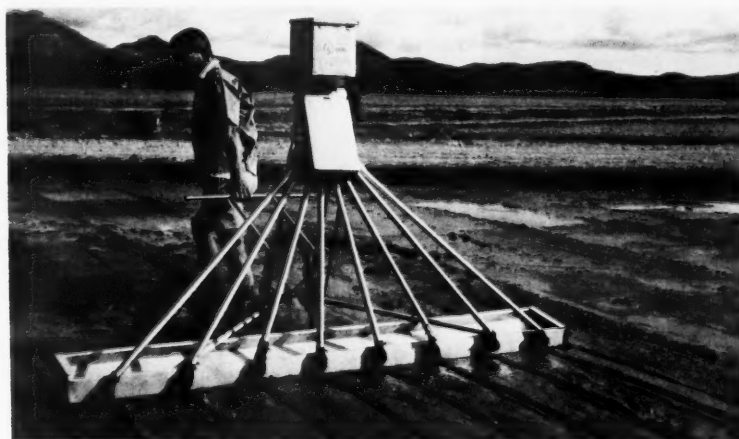
Power tillers. In contrast to tractors, the potential growth in demand for power tillers is considered to be high. In 1973 the tiller population was estimated at 8,000. The current market is for 5,000 units annually, conservatively projected to reach 10,000 units by 1980.

Until recently, the Philippines relied primarily on imports to satisfy its requirements for tillers. In 1972, for example, imports accounted for 85% of total power tiller sales numbering 1239 — i. e. 188 were locally made. During 1973, sales of tillers jumped to 2,456, and sixty-five percent of sales, or 1,609 units, were locally produced. Porter attributed this radical change to greater rural incomes and the availability of IRRI-type tillers.

### Production in Other Countries

After production in the Philippines had begun, a program to promote the manufacture of IRRI-designed equipment in 10 Asian countries (India, Indonesia, Korea, Malaysia, Pakistan, Philippines, Sri Lanka, Taiwan, Thailand, and South Vietnam) was initiated. Under the provisions of this program, IRRI sends models of the equipment designed for Philippine needs to subcontractors in each participating country for testing and evaluation under the conditions in their countries. Subcontractors are usually research institutes, but in some cases business firms. Results of the tests are carefully recorded and returned to IRRI. By the end of 1973, 120 IRRI machines had been delivered free of cost for such tests with the hope that producers would become interested.

There have been a few successful ventures in Thailand, Indonesia, and Sri Lanka, but the program on the whole has been relatively unsuccessful. The IRRI machines may be mechanically sound, but the majority of subcontractors have not been able to provide market studies which could interest manufacturers in building them. A second reason for the limited success of the program arises from the lack of close contacts between the local manufacturers and IRRI technicians. Insufficient funding and manpower for the program have precluded active on-site participation by IRRI engineers, which in turn has impeded the production in the participating countries. Thirdly, native engineers often work in government research institutes which are relatively isolated from industry; they have little or no experience in working with technology to make it commercially viable. The AED is now concentrating its efforts on a formalized industrial extension program in Thailand and Pakistan, to overcome the problems noted.



Seeder

RIGHT: Grain Cleaner



Foot Pump



Hand Weeder

Several Latin American countries have shown interest in IRRI designs. Field tests have begun on several types of equipment, and in a few cases machine shops have begun building their own prototypes for demonstration to farmers. A traveling exhibition of IRRI equipment will shortly be taken to Latin America.

### Some Problems and Recommendations

The experience with introduction of IRRI-designs to machinery producers in the Philippines points to several problems not fully foreseen when the project was initiated, and which may also appear when similar production gets started in other countries. Some of these are the kinds of difficulties to be expected in launching any kind of "infant" industry making new, reasonably complex products. Other problems arise from the relations of small and large firms, given that IRRI technology is available without cost to all of them. A large firm like Marsteel, with ready access to credit, engineering skills and market outlets will, on the one hand, help to develop the market and encourage production by small shops, but will also retain advantages in the competition which ensues. It will be better able to buy materials and imported components in bulk at lower cost, to incorporate later innovations more readily, to market its machines more aggressively, and to cut prices temporarily to drive out smaller competitors. Large firms have less need for technical assistance from IRRI engineers whose time is limited. The larger firms are also joined in the Agricultural Machinery Dealers Association (AMDA) which can lobby for their interest; few small firms can afford its membership fees. It was not IRRI's intention to benefit big, powerful companies. A useful counter-move, therefore, would be the formation of a separate small-firm association, which could: establish a system of bulk purchase for its members; obtain technical assistance; run a clearinghouse of information on government contracts, export openings, and new technologies; and represent member interests in various quarters.

Concerning the role of government: the Philippine government has given priority in its current Four Year Plan to maximization of employment, more equitable income distribution, and the promotion of regional development — goals to which the localized production of small-scale farm machinery by labor-intensive, small shops could contribute. The government has organized a number of institutions to foster small business, and to get credit to smaller farmers (helping them to buy equipment among other things); and bank regulations are intended to follow the above priorities. But all such special institutions are necessarily limited in scope by funds, personnel, and often by their location in only a few areas. Regulations can only partly overcome the tendency of bank practices

to favor the larger firms and farmers. In order to more effectively pursue the Plan priorities mentioned, and especially to reach the more remote areas, a network of multi-purpose provincial assistance and information centers could be of considerable value, both to the economy generally and incidentally to the IRRI program.

[ Extracted from: 1.) The IRRI Small Agricultural Machinery Project, an unpublished study (still incomplete) by the authors and others for the U. S. Agency for International Development, 1975/76; and 2.) an unpublished study they made for the National Science Foundation. Much of this material will appear in a chapter of Technology Transfer and U. S. Foreign Policy, Praeger and Co., New York, publication 1976.]

# MOTIVATIONAL TRAINING



WORK-ORIENTED ADULT LITERACY  
PROGRAM, ECUADOR (PHOTO: WORLD BANK)

## Results of Motivational Training in Ecuador

James C. Frits

[ Motivational training prepares its participants for development projects, makes them more self-confident and open to new ideas, helps them understand other people and work better with groups, and may furnish an important new factor in the development equation: these are among the findings of the evaluation study of a motivational training project of AID recently completed in Ecuador. The methods used in this training are briefly described. ]

A search for unexplored ways to make development more effective began in 1967 when the staff of AID (the United States Agency for International Development) in Ecuador reflected on the frustration and disappointment that often follows development programs. Most planners have seen development as an equation that included capital, technology and organization-building. Most development assistance programs contained all three elements, usually with greatest emphasis on the first or second. Dr. Hayes Keeler of AID/Ecuador thought that another element might be included, one which centered around individual growth and changes in individual outlook and behavior. He suggested an equation of four elements: Capital + Technology + Organization Building + Individual Growth. Development was thus defined in a much broader sense than economic and technical progress embodied in roads, dams and factories. As Keeler put it: development is increasing the capacity of individuals to guide and influence the direction of their own lives. While this definition includes greater material well being, it also implies that individuals will increase their self-respect and understanding.

Dr. Frits is the Behavioral Science Advisor for AID in Quito, Ecuador.

### Formation of Training Center

Beginning in the late 1960s, AID/Ecuador experimented with various kinds of training — behavioral, motivational, experiential — in a search for effective ways to bring the human development element into the programs it funded. By 1970 AID officials had become convinced that human motivational training was indeed an effective tool, judging from the reactions of participants in the training as well as from the results of an on-going sociological study. They felt, however, that such training would be more effective if it were carried out by an Ecuadorian organization rather than by foreigners. The Ecuadorian trainers who had been working directly for AID then organized a non-profit Ecuadorian corporation called CEMA (Center for Motivation and Advisory Services), and a four-year agreement was signed with AID to help the new organization find its role. By now AID has ended its support, and CEMA has become self-sustaining with contracts from Ecuadorian private clients and government departments along with the U. S. Peace Corps.

CEMA training. Because Ecuador is a country in which most of the rural people are not only illiterate but are held in subordinate positions within a strongly hierarchical system, CEMA emphasized the development of leadership qualities among villagers as well as in school teachers, health workers, and other urban-educated rural workers. CEMA trainers were and are bucking a traditional and oligarchic social and political structure which makes it difficult for the poor to obtain justice and participate in the material and other benefits of modern society. The traditional tendency of rural people is to look to the local "patrón," the government, or the church for the fulfillment of their needs, rather than striving to improve their lot by their own efforts. Motivational training was seen as a way to change this by changing the actions of rural people themselves. As individuals they may be relatively helpless; with the right kind of leadership, they could accomplish far more as a group.

CEMA trainers concentrated on skills that would help Ecuadorians in general, and campesino leaders in particular, to change their self-image. This involved "sensitivity training," a method of bringing a group of people not previously acquainted together for most of the day in seminars lasting one to two weeks, in order to get to know each other very well. In this way each trainee learns to understand other peoples' reactions to himself and how to manage his behavior in a group. (These are called T-Groups; some of the concepts used in this training were need-achievement, transactional analysis, and grid analysis.) The training also included "organization development," designed to help participants to form and sustain groups to accomplish various purposes. Later CEMA added training in a few other skills to suit the needs of specific clients.

The majority of CEMA trainees were "change agents," either local campesino leaders or people who worked directly with campesinos at the village level, such as social workers from the Ministry of Social Welfare or volunteers from Servicio Ecuatoriano de Voluntarios — a VISTA type of organization of volunteers. They received either one or two week motivational training seminars adapted to the needs of their specific project. Others who participated in week-long seminars were primary school teachers, principals and supervisors, university students, and normal school teachers. CEMA also organized shorter one-to-three day workshops for the Ministry of Health; between 1971 and 1974, these were offered to 484 village level health promoters, doctors, and paramedics, malaria eradication workers, home economics agents, nurses, social welfare workers and various health program community volunteers.

In general, the CEMA seminars tried to help participants become more accepting of change and better able to initiate it. As a culmination of the seminar experience, participants often wrote up a work plan to apply the techniques learned to their personal work style, and most seminars had later follow-up sessions to consider and revise the work plans. For instance, the campesino leader seminars provided practices in such leadership skills as discussion leadership abilities, communication skills, problem solving, decision making, collaboration with others, increased participation in programs, observation and evaluation. Teachers learned how better to introduce new teaching methods, health workers how to serve their community more effectively, etc.

#### Evaluation of Motivational Training Effectiveness

After three years of support to the new organization, AID officials wanted to know whether or not this type of training was meeting the goals which planners had set for it, and a study of the effect of CEMA training was commissioned in 1974. This study examined a stratified random sample of 86 respondents from the 1298 CEMA participants in three major categories: Education, Health and "Change-Agents," who had taken training between January 1971 and June 1974. (Change agents will be used from here on to designate local community leaders, plus non-rural workers in rural areas who had no conventional profession.) It also studied a modified control group of similar composition, and used post-test scores to determine differences between former CEMA participants and the control group. The data on the control group made it possible to compare CEMA-trained leaders with similar community residents who had received no such training. Data were collected using an interview schedule, partially unstructured, a time budget analysis, and miscellaneous supporting devices. Interviews were designed to find how much the training experience

had influenced the attitudes of the trainees in particular ways, and whether it had actually helped them in their work.

Finding of the study. CEMA's goal was to serve the rural population indirectly by attempting to change the attitudes and behavior of potential leaders rather than those of the campesinos. A majority of the sample studied were well-educated, much better than the average of the Ecuadorian population: 62% of the ex-trainees had 12 or more years of education, while 22% had 7-12 years; only 13% had 4-6 years and 2% less than three years. More than half the ex-trainees were in positions that required at least a high school education (health workers, school teachers, principals, etc.). Nineteen percent of the sample were school teachers, 15% were school supervisors or directors, 35% were health workers, and 31% were change agents (as defined). The education level is important since, as will be seen, the change agents, who generally had the least education, showed the greatest effects from CEMA's training.

One of the most important factors explored by the study was human motivational training's effect on Awareness, a dimension the study defines as including a number of qualities illustrated in what follows below. It was found, for example, that training significantly increased Awareness in making participants more open to new experiences and ready to see more alternative possibilities in a given situation, and also in helping them think about democratic principles. Almost all indicators for Awareness, as inferred from analysis of the interview results, demonstrated higher mean scores for ex-trainees than for controls.

One indicator of Awareness is the degree to which an individual is willing to criticize his organization. More aware individuals have enough self-confidence to state openly their views about their organization or community and to make critical comments. Some 45% of the ex-trainees said they would criticize their organization or community compared to only 21% of the controls. The use of formal or informal address with colleagues is another indicator of Awareness. CEMA stresses a "climate of confidence," in which all participants are co-equal companions. They encourage the use of the familiar form of Spanish for "you" (tu) within the training groups, which included people of different social levels. 57% of the ex-trainees used this form as contrasted with only 41% of the controls.

To determine Awareness on an authoritarian-democratic continuum, ex-trainees were asked if they resolved conflicts by exercising their authority. Ex-trainees appeared to be more democratic in that fewer stated they resolved conflicts by exercising authority than did controls. Awareness on this authoritarian-democratic continuum is also indicated by the acceptance of others' ideas for making organizational or commu-

nity decisions. CEMA ex-trainees scored much more strongly toward the democratic side than did controls: more controls (47%) felt it was necessary to make decisions on their own than did ex-trainees (30%).

Persons aware of alternative possibilities tend to believe they can personally affect their own destiny, i. e. dominate their environment enough to advance their own purposes or goals. To be innovative, an individual cannot be fatalistic and must feel he has some control over the future. More control respondents believed that government actions "are always more important" than individual efforts (35%) than did ex-trainees (17%). Particularly, ex-trainee change agents had little faith in the government's ability to carry out effective programs or projects. Fewer change agents (26%) believed the government can do better than individuals, while 45% of the educators thought so as did 43% of the health workers (the latter two were, of course, government employees). Similarly, the person who sees alternative possibilities is less likely to see opinions from a hierarchical or autocratic view. Instead of policy-making based on respect for tradition, the "aware" person favors discussion and constructive conflict. CEMA ex-trainees stated overwhelmingly (77%) that they "always" or "almost always" prefer discussion and conflict, compared to the controls (61%).

In general, the study found that CEMA motivational training made all ex-trainees more aware of their personal worth, have stronger feelings about what they can do as individuals, and be less autocratic than others. Among change agents there were dramatic differences between ex-trainees and their controls on four questionnaire items especially included to measure their application of these values to their methods of work: priority given to initiating work plans for community development; use of group dynamics in their work; emphasis placed on motivating people as a strategy to complete community objectives; becoming aware of specific skills one has (self-confidence) to complete projects. The study also explored the degree to which attitude and value changes appear in the area of work style. Ex-trainees consistently stated that work groups were more effective than working alone, while a majority of the controls would "always or almost always" put ideas into practice by themselves. Ex-trainees thought it was better to plan strategies and objectives through groups, and that it was important to participate actively in work plans of an organization or community. They felt they could learn work skills more easily with groups, and they had more positive attitudes about giving information to work organizations.

The study also points out that motivational training has a "halo" effect immediately after training terminates. Trainees felt immediately motivated; and many began to practice working in groups, tried

new human relations techniques, increased their planning and organizational activity, began to provide more information to others. Other ex-trainees, however, said they were motivated but also frustrated. When they returned to a normal, traditional Ecuadorian work environment, many simply could not initiate, perform or otherwise use their CEMA training because they hold jobs with great restrictions and lack of opportunity. School teachers, in particular, felt great difficulty initiating new teaching methods which were not approved or understood by their principals or supervisors. Health workers, on an average, seemed to have more success than teachers applying their new skills since they often work alone in a community setting where they can change methodologies and techniques at will. Change agents had the greatest success applying their new skills. They usually work without supervisors, and generally with small groups, so that almost everything learned from motivational training could be readily applied to their work and goals.

A factor analysis of items on the study's structured interview confirmed the remarkable results among the change-agents. The action results of their training were greater when compared to health workers or educators, both of whom must work through bureaucratic organizations with strong cultural and official resistance to change. Whereas the ex-trainee health workers and educators scored higher than their corresponding control groups on 67% of the items relating to actions, the change agents scored higher on 90% of these items.

Considering the short period of CEMA training seminars and the great time lapse for many trainees between training and the study, its authors concluded that CEMA had been extraordinarily effective. However, the study could not find objective evidence that motivational training alone had led to social and economic change. It found the CEMA-induced human growth skills important as bases for developmental change and for the success of projects, but the effects of these new skills were often negated by outside forces such as cultural obstacles and intransigent bureaucracies. Nevertheless, it is clear from the study that development organizations have available to them a new tool to enrich their programs. The years of experimentation in Ecuador show that motivational training is a valuable aid, that its techniques can work with a variety of people in a variety of settings, and that it has in fact contributed to the successful outcome of a number of AID projects in Ecuador.

[ Extracted from an unpublished paper, September 1975. ]

Note: As this issue was going to press it was learned that another version of this article will appear in the "Focus" portion of the International Development Review, and that Dr. Frits has been transferred to the AID Mission in Panama.

## Sarvodaya Shramadana in Sri Lanka

A. T. Ariyaratne

[The Sarvodaya Shramadana Movement may be regarded as supplying a form of motivational training to its participants. Its methods are indigenous to Sri Lanka and Asian in origin, unlike the training described in the preceding article using methods originating in Western social science. The developmental objectives of the two methods have numerous similarities, though they are not identical.]

Sarvodaya Shramadana is a movement dedicated to a nonviolent social change based on the traditional culture of Sri Lanka. "Sarvodaya" means awakening or "liberation of all" and "Shramadana" is "gift of labor." Sarvodaya Shramadana calls on every person to use whatever mental and physical energy he possesses for the well-being of all. Such a movement has to work from the grassroots — from the village up. Already the movement which began with one village 17 years ago has extended programs to 600, and the target for the next three years is a thousand villages.

In each of these villages one or more youth leaders has voluntarily organized the community to carry out self-development. They keep in close touch with Meth Medura, the headquarters of the movement situated in the outskirts of Colombo, which coordinates all these activities on a national and international scale. Attached to the headquarters is the main training center for village level workers where at any time 300 young men and women are training in community leadership, agriculture, village technology, and all other techniques

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necessary for social change beginning at the village level. To date there are 1200 other youths in over 20 centers throughout the country engaged in a variety of cooperative agricultural and small industrial pursuits — all carried out on a basis of sharing and living a communal life.

Buddhist monks who have been respected for generations as the strongest social leadership force also have joined the movement in large numbers. There are six training centers for training monks to lead in village reconstruction. With these activities the Sarvodaya Shramadana Movement is by far the largest non-governmental development organization in Sri Lanka, bearing direct influence on at least 80,000 families. What is perhaps unique in the Sarvodaya Shramadana experiment is its conscious endeavour to harmonize the ancient with the modern. Sarvodaya was not built on preconceived ideas. It was a natural growth of a people who desired to develop by their own efforts, and who believed in greater participation in decision-making and implementation of programs that affected their lives. The experiences gained and lessons learned at each stage of the evolution of the movement provided its members with the resource material from which the ideology, the strategies, techniques and the organizational framework grew. Even today, with every new challenge, the Movement readjusts itself to achieve its target of building a new society from the village up.

#### Shramadana Camps

The path to this new society begins with the 'awakening' (Sarvodaya) of individuals, families, and village communities to their own potential. People come to understand they can make and carry out their own "development plan" to meet their own needs. They do not need to be mentally and physically dependent on what is handed down to them by distant bureaucrats and politicians.

Villagers wishing to be assisted by Sarvodaya are visited by Movement staff, and together they identify the most pressing need of the village that could be met by physical labor. This may be restoration of an ancient irrigation tank (water reservoir), the construction of a new tank, the cutting of a new road or the rehabilitation of an existing road, or any similar project. Sarvodaya then helps the village to organize a big Shramadana Camp to tackle this project, using local villagers, reinforced by other villages already involved in the Movement, and by Sarvodaya volunteers from towns and cities. A strict code of self-discipline is followed in these Shramadana camps with six to eight hours of each day devoted to physical work, and three to four hours of education through dialogue, song and dance.

The purpose of these Shramadana camps is to catch the attention of the villagers to demonstrate that some solutions to their problems

lie in their hands (literally and figuratively). Various village organizations — a children's group, a young people's group, a mothers' group and a farmers' group — are created. Through them, villagers discuss with each other and then, if necessary, with the representative village council, their problems, needs and wishes, and together take whatever action is required.

Philosophical base. These groups also spend time discussing the Sarvodaya philosophy — a Gandhian philosophy which incorporates elements of Buddha (Buddhism is the predominant religion in Sri Lanka) and other major religions, as well as pre-colonial Sri Lanka rural culture. The major long-term goal is non-violent social change. The Sarvodaya approach is not ivory tower philosophizing but is based on very practical rural development actions carried out by villagers themselves, assisted by Sarvodaya's resources of workers, skills, facilities and funds and making use of the Government's assistance where available and relevant.

Shramadana camps lay the psychological infrastructure necessary for making people think, plan and work together. Groups in the community develop a social infrastructure that helps them identify problems pertaining to each group and plan solutions to these together. Development education institutes and training centers run by the Sarvodaya Movement help indigenous rural leaders, especially youths, to develop correct attitudes towards development and implement projects realistically and successfully. A revolving fund, called Gramodaya (Village Re-awakening Fund), advances loans to village groups on easy terms to supplement their capital needs. Excess produce from the village can find its way to national markets through the Sarvodaya Mini-Market in Colombo without the intervention of middlemen. Even international markets for their produce are open through the Sarvodaya Training System which has established links with world shops run by fraternal organizations in rich countries.

An ideological integration results from emphasizing the spiritual and cultural values in all programs. Meditation, traditional customs and ceremonies, and song and folk dances, form an integral part of Sarvodaya activities. Sarvodaya is a living, growing movement that each year attracts an increasing number of people. Sarvodaya believes that change in the world begins with change in countries; that change in countries begins with change in local communities; and that change in local communities begins with change in individual people.

### Strategy for Change

1) In the developing world there must be a definite governmental recognition of the role of voluntary agencies, not only in providing social services but also in bringing about non-violent changes in the structures of society for social justice. The role they have to play may change from country to country, but participation is a must.

2) The political and economic power of the country must be decentralized to facilitate maximum participation of the people in the planning and the implementation of social and economic policy.

3) A complete overhaul of the book-centered, examination-based, socially fragmented, competitive educational system must be undertaken to make it meet the needs of the totality of the community.

4) While not causing any embarrassment to the sovereignty of the national government, the free movement of voluntary workers and material resources must be encouraged under the authority of national and international voluntary organizations which have proved their integrity, worth and non-commitment to political struggles. Perhaps the UN can undertake this responsibility by arrangement with national governments and enter into agreements to bring cooperation for self-development across ideological frontiers. The approach to cooperation between the voluntary organizations in developed and developing countries must not be confined to the exchange of volunteers. There should be an effective information exchange program concerning what prevents the poorer part of the world from developing, and a consistent effort by voluntary bodies in the developed world to press for economic justice for the poor world.

Development is not the product solely of assistance from the wealthy nations. As the Sarvodaya Shramadan Movement has shown, people in the poor countries can be mobilized to help themselves.

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# PRICING POLICY



A CONSUMER CO-OP IN LAGOS, NIGERIA  
(PHOTO: INTERNATIONAL LABOR OFFICE)

## Government Product Pricing in Korea

Gilbert T. Brown

[The prices fixed for products produced and sold by government enterprises are frequently important, both to consumers and to national development. This article examines pricing policies in four Korean industries — electricity, telephones, coal, water — and concludes that policies aimed at establishing market equilibrium prices are highly beneficial; contrary policies have been disadvantageous.]

Government enterprises are an important part of total economic activity in many developing countries, including South Korea. The privileged access they usually have to credit and saving via the government budget and the banking system, and their greater freedom than the private sector from market forces, can have important effects on prices, output, and the allocation of saving and investment. In addition, such enterprises often provide basic goods and services affecting the real incomes and welfare of lower-income groups, a fact which looms large in debates over their pricing, financing, and other policies.

The Korean government assumed ownership in 1945 of all Japanese-owned enterprises, and it has retained some which have a public utility nature or a strong monopoly position. Among these is the Communications Special Account which includes the postal, telephone, and telegraph systems. The Korean government is also a stockholder in more than thirty "government invested corporations," most of which also have private stockholders. These firms include the Korea Electric Company, which has a

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monopoly on the sale of electric power, and a corporation which produces 40 percent of the nation's coal. This article will discuss the pricing policies during the 1960s of the three enterprises mentioned, plus those of municipal waterworks. The industries selected illustrate problems in several different types of market, all of which have some national importance. The consequences of particular prices, and the pertinent social costs and benefits will be examined.

Collectively, the Korean government enterprises and government-invested corporations produced 6.5 percent of value added, 15.8 percent of national saving, and financed nearly 10 percent of gross national investment. Their savings (profits plus depreciation) have amounted to more than two-thirds of their own gross investment, with the remainder financed mostly from the government budget and by bank credit. Thus, these enterprises have financed from their own revenues a majority of the capital formation for railroad, electric power, telephone, telegraph, postal, and other government-invested enterprises. To do this, the prices charged for goods and services must be high enough to cover their current costs of production and beyond that to generate a substantial surplus of revenue to help meet investment needs. This policy is in marked contrast with the experience of a number of countries where many such government-owned enterprises operate at substantial deficits, so that significant sums of general government revenues must be used just to meet these deficits, and where new investment must be financed by further government expenditures and by borrowing from the private sector.

#### Korea Electric Company

The Republic of Korea was short of electric power from the time of the division of the country in 1945 until the early 1970s. In 1946 and 1947 South Korea purchased two-thirds of its total electric supply from North Korea, but that supply was cut off in May 1948. Power barges with diesel generators, small diesel generators for individual users, and other equipment was hastily purchased and borrowed to meet this crisis. Supply seemed momentarily to have caught up with demand for the first time in 1965, but this illusion was quickly shattered when an easing of restrictions on the use of electricity and rising levels of income produced an outburst of new demand that soon led to renewed "brown outs" and power shortages that threatened to stifle economic growth. Given this chronic condition of short supply, the basic decisions in electric power have been those of pricing and investment.

The basic priority of the power program during the 1960s was to expand generating capacity sufficiently to meet the power and lighting needs of industry and commerce, and secondarily to provide for a

steady expansion of household lighting service. Rural electrification programs made some progress in bringing service to farm and fishing villages, but the high investment cost per revenue yield on such service caused this program to move relatively slowly before 1970 because of the intense competition for investment funds for other uses.

The pricing structure of electricity is consistent with these allocation priorities, with lowest rates for irrigation and large power service and highest rates for households. Except for irrigation uses, however, these relative prices also tend to reflect differences in the relative costs of providing electricity to these alternative users. Since 1961, however, the price of high tension service to large industrial users increased by 81 percent, compared to 36 percent for regular service to smaller users. Special discounts are given to those using power to produce exports, to producers for whom electricity accounts for more than 20 percent of the cost of production, and to municipal water companies.

Two crucial decisions for future power development were made in 1961 which set policies for the decade. The first was to raise electricity prices by 50 percent to create profits from which to finance the expansion of the electric supply, and to encourage economy in consumption. The 1961 price increase was followed by another 50 percent increase in 1964, and smaller increases in 1966, 1967, and 1969 (table 1). The second 1961 decision was to merge Korea's three electric power companies into one company, the Korea Electric Company (KECO) to achieve operating and managerial efficiencies. These actions shifted the electric company from a deficit to a profit position. In constant prices, the price of electricity rose about 10 percent between 1960 and 1962, while its cost of production and distribution declined by 40 percent; between 1962 and 1970 it fell by another 50 percent. The reduced costs reflected the establishment of a nationwide electric distribution grid, system-wide planning, reduced managerial overhead, and expansion of lower-cost categories of service.

Electricity pricing has been important because the critical problem restricting the expansion of generating capacity throughout the 1960s has been lack of financial resources. The cost of equipment could have been financed through foreign borrowing, but borrowing for power generation would have reduced the availability of foreign credit for other purposes. The domestic currency (won) costs of site preparation and plant construction were also considerable. KECO's prices since 1962 have generated profits equal to one-fourth to one-third the value of sales, and a ratio of profits plus depreciation equal to more than one-half of value added. Annual profits plus depreciation during 1964-68 amounted to 30.5 billion won (in current prices), of which 3.3 billion won was paid in dividends to private

stockholders. The remainder was available to finance new investment. The total won and foreign exchange cost of additional generating facilities completed during that time, which increased installed capacity from 465,000 KW to 1,274,000 KW, or by 174 percent, was only 47.8 billion won. Thus KECO's gross savings were more than 60 percent of the total cost (and 173 percent of the won costs) of this newly completed capacity.

The rapid growth in industrial production after 1965, as well as increased nonindustrial use, resulted in a far more rapid increase in demand for electricity than had been thought possible. Increased availability of electricity caused small industry to increase its electricity use by about 35 percent per year. Total electricity sales, which were limited by supply rather than demand, grew at a 27 percent annual rate during 1967 and 1968, compared with only 14 percent during 1955-61 and 19 percent during 1962-66. The proportion of

Table 1. Korea Electric Company Data<sup>a</sup>

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Percent of rate increases, current prices		50%			50%		25%	15%		10%		
Rated power capacity (thousand KW)	367	367	434	465	597	769	769	917	1,274	1,636	2,508	2,628
Power sales (millions of KWH)	1,136	1,213	1,508	1,683	2,035	2,452	2,989	3,883	4,850	6,358	7,740	8,884
Lighting	235	228	266	292	350	417	494	563	656	827	1,009	1,231
Power	901	984	1,242	1,391	1,684	2,035	2,495	3,320	4,195	5,530	6,731	7,653
Operating costs per KWH (1965 won)	8.0	6.7	4.8	4.3	3.1	3.2	3.2	3.2	3.2	2.7	2.4	2.5
Electric operating profits <sup>b</sup>	570	1,721	2,293	871	1,806	3,734	4,471	4,966	5,652	6,848	9,203	7,087
Revenues <sup>b</sup>	9,616	9,878	9,514	8,047	8,135	11,641	14,329	17,468	21,035	23,913	27,656	28,943
Expenses <sup>b</sup>	9,045	8,157	7,220	7,175	6,328	7,907	9,587	12,502	15,383	17,065	18,453	21,856
as a percent of sales <sup>b</sup>	5.9	17.4	24.1	10.8	22.2	32.1	33.1	28.4	26.9	28.8	33.6	24.7
Profits, all operations <sup>c</sup>	- 439	645	1,483	862	1,169	2,822	3,180	3,887	3,750	3,966	5,526	2,814
Depreciation	n.a.	n.a.	n.a.	n.a.	1,541	1,775	2,460	2,518	2,723	3,399	3,646	3,866
New investment in generating capacity by year of project completion	n.a.	n.a.	4,658	2,651	8,262	12,512	0	6,118	14,287	8,320	18,432	12,004

Sources: Data from Korea Statistical Yearbook, 1971 and earlier years, and Economic Survey 1969, both published by Economic Planning Board; Financial Statements Analysis 1967 and Financial Statements Analysis 1960-1966, Bank of Korea, and Korea Electric Company.

a/ Figures are in millions of 1965 won unless otherwise indicated.

b/ Excludes street railway operations (which ended in 1968), and nonoperating revenues and expenses.

c/ Includes street railways and nonoperating revenues and expenses.

electricity going to smaller industrial users fell from 14 percent in 1960 to 9 percent in 1967, while the share to large industrial users, such as cement plants, rose steadily from 64 percent of the total in 1960 to 75 percent in 1967. Household consumption and other lighting was allowed to expand, but less rapidly than the growth of capacity. The number of household customers doubled between 1960 and 1967, however, and rose by another 7 percent in 1968. Furthermore the quality of household service rose as those receiving flat rate service (100 watts of attached power, or three weak light bulbs) fell from 62 percent of the total in 1960 to less than 6 percent in 1967. By 1968, most urban dwellers had electricity, but two-thirds of rural families did not because of the high costs of providing such service.

Higher average electricity prices produced important welfare benefits because of their role in increasing the overall level of saving and bringing the supply of electricity closer to the quantity demanded. The increased power supply made possible by the saving generated by higher prices permitted industrial production and employment levels to rise considerably more rapidly than they otherwise could have. Between 1964 and 1970 electricity sales increased by 3.8 times, constant-price operating costs declined by 23 percent, and saving from electricity operations (operating profits plus depreciation) increased by 3.8 times. These savings in 1970 were equal to nearly one percent of gross national product. While the welfare consequences of such a change cannot be measured directly, there are substantial benefits to offset the welfare loss from reduced consumption that may have occurred because of higher prices. This is particularly true because any tendency toward reduced electricity consumption by lower-income groups due to price increases was at least partly offset by the increased saving and investment, and the lower real cost and price of electricity and its increased availability over time, both of which served to increase the consumption of electricity by lower-income groups.

To have diverted more of the existing supply of government resources and/or bank credit to financing for KECO would have reduced the growth of investment in other areas. To have gone the alternative route of additional government deficit financing would have further inflated the money supply, which would almost certainly have further increased the rate of inflation and slowed the growth of private saving and of government revenues. The only other option would have been to have used more foreign saving, as was done to meet the requirements for investment in electricity in 1967-68; but the limit to a country's foreign debt burden would also have meant that less foreign capital would have been available for other uses.

It could be argued that prices of electricity should have been even

higher than they were, at least prior to the appearance of excess capacity in 1970-71. Many potential users who could not obtain service would have undoubtedly been willing to pay somewhat higher prices in return for increased service. A higher price (up to the short-run equilibrium level) would not have meant reduced total consumption, but would have perhaps reduced consumption by some users offset by increased consumption of others until such time as new investment increased the total supply of electricity and lowered its costs. Higher prices would, of course, have meant yet more internal saving and less domestic or foreign borrowing.

There are no meaningful data to measure the effect of price increases on demand for electricity. The shortage of supply determined the total volume of sales, and rationing devices as well as price differences affected the distribution of sales between customers. There is definite evidence that prices have been high enough, however, to curtail many demands. One is the relatively low level of lighting in Korean factories and places of business, as well as homes. Also, the low-power-consumption neon tube is much more common than the ordinary incandescent light bulb, since its higher initial cost is quickly offset by the savings on electric current. Also, the high price of electricity for household use has so far prevented any very widespread demand for household appliances such as electric irons, air conditioners, fans, toaster, and the like, especially the high-wattage items. There is demand for electric washing machines, for example, but none for electric clothes driers. The same economizing on use of electricity is seen among industrial and business users. Expected electricity requirements have been one factor considered by the Economic Planning Board in approving applications for foreign financed investments.

#### Telephone Service

Demand for telephone service in Korea has always outstripped supply, and there is an active black market in the sale of telephone service. The waiting list for telephone installation is long, and the time between the request for service and its installation is normally one to two years or even longer unless one resorts to the black market. The black-market prices for prompt installation in Seoul are published regularly by a Seoul newspaper, and are generally about one and a half to two times as high as the official charge. Published data on the Communications Special Account are inadequate to make an estimate of profit and saving on telephone service alone, since the entire postal system, telegraph system, and part of the radio system are also part of the same special account. This special account has been operated on a net profit basis. Domestic telephone revenues constitute about 40 percent of total revenues of the account, and telephone service is believed to be its most profitable operation.

Telephone prices have been increased less often than those for electric power, and have remained well below market equilibrium. Customers and the general public would probably have benefited from higher telephone installation and service charges in the 1960s. The increased revenue from prices closer to the short-run equilibrium level would have provided additional saving to speed up the installation of additional switching offices, lines, and individual telephones. The public could have had more extensive and better service, and there would not have been as much delay and payment of bribes in order to get service. The actual cost to customers of installation charges closer to the market equilibrium price would have been very little: a near doubling of official installation charges in 1968 had almost no effect on black market prices for immediate installation. At the end of 1968 these were 150 to 200 percent of the official price, compared with 250 to 375 percent a year earlier.

The reasons most often given for not raising telephone prices were to keep down the cost of service for lower income groups and to help fight inflation. Neither reason is convincing. Many and probably most middle-income families could not afford even the official installation charge, which in Seoul in 1968 was 90,000 won (\$300), or nearly twice the per capita GNP. Thus the practical question is one of access of middle-income families, not lower-income groups. The installation charge seems high in comparison to the 4 won charge per local call. The low per-call charge permits low rates on public telephones, and thus lends some air of credibility to the argument for keeping prices low for low-income groups. But unless one has rich friends or relatives, the phone is useful only for calling larger business establishments or government offices, which poor people do much less than their richer neighbors. It appears that middle-income groups would benefit from higher per-call charges for phone service and the resulting use of the additional revenue to expand phone service. More rapid expansion of phone capacity has been a prerequisite to making more service available to moderate-income groups, since this is a decreasing cost industry and demand has consistently exceeded capacity at existing prices as reflected in the black market prices.

#### Coal and Coal Briquet Prices

Briquets made from coal are Korea's principal heating and cooking fuel in urban areas. Government attempts to control the price of coal briquets, at less than short- and long-run equilibrium levels have caused a welfare and economic loss in the last half of the 1960s to consumers (particularly low-income families) and coal miners, reduced national saving and investment, and caused damage to the coal industry and to Korea's balance of payments. In May 1961 the government imposed price ceilings on private as well as

government coal mines. After rising costs led to the closing of many private mines, the government removed price controls on privately produced coal in mid-1964 and a few months later raised prices of government-mined coal. Price controls were retained, however, on the 11 pound briquets that were virtually the sole household fuel. More than half of total coal production went into making briquets, and it was argued that their prices were too politically sensitive to permit larger increases and that it was necessary to "hold the line" on briquet prices to help fight inflation and protect lower-income groups. The unfortunate consequences of attempting to control briquet prices in the face of rising coal prices, however, were many.

Briquet makers reacted to price controls and the profit squeeze in several ways. First, they reduced the quality of their briquets by using more clay and less coal. Consequently more briquets had to be used per day to provide the same heat, and it became more expensive to use the poorer quality briquets than it would have been to pay a market equilibrium price for briquets of the previous quality. Second, during much of the spring and summer of 1966 briquet makers refused to buy coal or manufacture, creating a backup of coal at the mines and the threat of a fuel shortage. Third, once the crisis became evident, dealers ignored the 8.5 won per briquet price ceiling and the typical going price became 15 to 16 won apiece, and in some areas higher. In October the government partially acknowledged the situation by raising the ceiling price to 12 won.

The government then tried to depress coal and briquet prices by increasing the supplies of available coal. To deal with the threat of a fuel shortage in late 1966, the railroad gave top priority to moving coal, even at the expense of costly delays in moving other commodities, including badly needed lime for the barley crop. Second, the government tried to channel as much government-mined coal as possible to briquet manufacturers because its price was cheaper than that of privately mined coal. The Korea Electric Company was ordered to use oil rather than coal in all generating plants capable of burning either fuel, even though this increased the fuel cost of these plants by at least one-third. Because delivery costs were higher to smaller users around the country than to power plants, and its coal was sold for the same delivered price in all locations, the government coal company became a deficit rather than a profitable operation. Furthermore, the government imported duty-free from Japan large numbers of kerosene space heaters and encouraged the use of other oil heating equipment, imported large quantities of heating oil to meet immediate needs, and began drawing up plans for much of the future increase in fuel needs to be supplied from expanded domestic refinery capacity as well as direct imports.

Because of the greater convenience and cleanliness of oil heat and the uncertainties about the availability and price of briquets, most

middle- and upper-income families bought the petroleum heaters for use at least in the spring and fall when the demand for heat is intermittent. These households have also kept their briquet-burning facilities, however, and continue to use these during the winter, when the need for heat is sustained and use of briquets is cheaper. The heating of large auditoriums and other facilities with only intermittent demand for heat has also largely shifted over to oil. Lower-income families, however, have generally continued to use briquets for all heating.

Government coal mine saving as well as profits have been negative in the years 1967 through 1970 due to prices often 20 percent or more below those of private mines. Therefore all investment and some operating expenses of government mines have had to be met from the government budget and from bank loans. As a result of increased competition from petroleum fuels, coal production fell by 17 percent in 1968, then remained at the lower level through 1969 before recovering to the 1967 level. This created considerable unemployment and hardship in coal regions. To encourage more coal mine investment and production, and to slow the growth of oil imports, the government increased the import duty on "bunker C" fuel oil from 5 percent to 10 percent in 1969, with the additional revenue earmarked for coal industry investment or subsidies. It has been a net loss to the economy to import oil for purposes for which domestic coal supplies are a cheaper and close substitute.

The welfare effects of government efforts to maintain coal and briquet prices below short-run equilibrium levels in the 1960s have almost certainly been negative. Lower-income consumers, for whom it was desired to keep briquet prices low, have been worse off because price controls actually raised their fuel costs by bringing about a lowering of the quality of briquets and (for several years) adding to their price through a scarcity value arising from uncertainty of supply. National savings were lowered by the deficits experienced by the government coal company, by higher fuel costs for KECO, and diversion of government revenue and bank credit from other productive uses to cover operating losses and finance new investment. Briquet dealers probably found their incomes increased in the short run as they raised their prices well above official ceilings, but in the long run have seen the volume of their business decline. National product was lowered and coal miners found themselves unemployed, even though they were producing an economically competitive product, because of government actions requiring certain consumers to use higher cost petroleum fuels, and because all petroleum and oil heating equipment was imported without tariffs or at very low tariffs, thus at a lower than average exchange cost for imports.

## Municipal Waterworks

Seoul, Inchon, and Taegu, three of Korea's major cities, undertook extensive water and sewage expansion projects during the last half of the 1960s. In these and other cities water and sewage facilities are owned by the municipality. Foreign loans were obtained to finance the cost of imported filtration, pumping, and related equipment. Other investment funds were obtained from government budgets and to a modest extent from bank loans. In each instance, however, water and sewage charges were raised in order to service all new debts and to generate funds for planned additions and replacements to these plants and ancillary facilities, including booster stations and additional storage facilities as well as pipes and pumps. The health benefits of good water and sewage facilities are so great that it can be argued that these facilities should be provided at a subsidized price in order to get universal use. The least costly way to increase the number of users, however, would be to charge prices adequate to cover the opportunity cost of capital and to use those profits to extend water supplies to urban areas (mostly low-income) currently without municipal water and sewage.

One interesting twist to the pricing schedule of the Seoul Water Bureau was that the basic household rate for water is the lowest per cubic meter rate for any users. In an August 1968 increase that raised overall water rates by 36 percent, rates for large water users were put on an ascending schedule, with monthly use in excess of 1,000 cubic meters being charged three and one-half times as much as the flat cubic meter rate of households. Smaller nonhousehold users pay a flat rate that is 50 percent higher than for households. Thus, an overall deficit in the cost of service is avoided, with larger users subsidizing lower rates for households and small-scale business users. Aside from possible welfare judgments, an increasing marginal price for large users is contrary to normal economic thinking and reasoning, since the cost of service to large customers is lower. This pricing system may have a sound economic justification, however, since it discourages large water users from locating in the Seoul area where water usage nearly equals the presently available supply, and where the capital cost of increasing the water supply would be quite high.

## Conclusions

For the enterprises reviewed, prices have been sufficient to cover current operating costs with the exception of coal in the middle 1960s, and varying amounts of surplus revenue were obtained which helped to meet investment needs. In assessing Korean pricing policies, it must be remembered that annual rates of inflation averaged 15.2 percent from 1960 to 1970, so that price increases were necessary just to keep up with rising costs. The price policy decisions noted

above were nearly always to raise prices beyond the current rate of inflation. Since all enterprises concerned were selling in markets where shortages of supply relative to demand could be observed (aside from electricity in 1970), the decisions to increase "real prices" were decisions to bring prices closer to equilibrium levels. It would appear that excess demand was never wholly eliminated (with the brief exception noted), as shown by capacity operation of plants, black markets, administrative rationing, etc. Nevertheless, the policies pursued were generally in a beneficial direction, for reasons specified in each case, and where there was movement away from market equilibrium in the case of coal briquets there was a net loss in welfare as a result.

Analysis of the pricing policies in four quite different markets strongly supports the conclusion that government enterprises should set the prices of their goods and services at levels that approach or approximate estimated short-run equilibrium prices. (This analysis is not intended to apply to basic governmental services or to education, which are generally best financed by taxes. Rather it is intended to apply where the enterprise is supported primarily by the sales of its products.) This means setting product prices at levels that will yield a rate of return on the capital used in their production comparable to that obtainable in alternative uses. Korean pricing changes in the period covered were quite consistently in the direction of moving toward opportunity cost prices, and thus the levels to be expected in the "perfectly competitive markets" world of economic theory in which such pricing maximizes total income by causing each factor of production to be used in that activity in which its productivity is the greatest. If the price charged for a product is less than adequate to yield the "opportunity cost" rate of return on its cost of production, this implies (among other things) that such a price is too low to generate adequate investment in its production.

To summarize the benefits of this policy: increases in product prices to bring them much closer to equilibrium levels resulted in increased national saving and investment, a more rapid rate of income growth per unit of investment, an improved balance of payments position, less inflation, lower costs and prices through increased output (i. e., greater economies of scale), and benefits to consumers generally and particularly to lower-income groups. Subsidized pricing has proved to be a grossly inefficient way to benefit lower-income groups, who got only a small portion of the outlays for such subsidies. Important administrative benefits were also obtained by raising prices toward equilibrium levels: it reduced demands upon administrative talent, one of the scarcest of developing country resources, to make specific allocation decisions among competing consumers. Another benefit was to reduce bribery and corruption by reducing the number of situations in which an admini-

strator could control the access of a specific consumer to a desired good, service, or factor of production. Also, closer to equilibrium prices made it possible to estimate much more accurately the equilibrium level of demand for specific marketables, and therefore to make better investment decisions and a more efficient use of investment resources.

The benefits of the savings generated in government businesses have been most obvious in the rapid expansion of basic infrastructure and other productive capacity which they have financed with relatively little demand on the government budget or the banking system and private sector saving. This is in marked contrast to the financial position of government businesses in many developing countries, where such enterprises often absorb an important part of tax revenues to cover operating deficits as well as investment costs. Raising a government enterprise price to bring it closer to an opportunity cost increases profits and savings (or reduces dissaving) for both the enterprise and the economy. This increase in enterprise and national saving creates the possibility of more investment in producing the product whose price has been raised when demand still exceeds supply at the higher price, or when there are important cost-reducing benefits. This has been the consequence in Korea of higher prices for electricity, telephone, and water services.

The usual argument against raising the prices of government-supplied products, which is a highly political decision in many cases, is that it hurts consumers, especially those with lower incomes. The higher price initially means reduced real purchasing power and income for consumers, but this is a temporary effect which is soon offset. Consumers necessarily readjust the use of their income, buying less of either the commodity whose price has been increased, or of some other commodity, and possibly saving slightly less. Consumers as a whole soon have greater real incomes than they would have had without the price increase, however, as the resultant increase in saving and investment increases levels of employment and output. The evidence in Korea is that it is the wage earners and lower-income groups who suffer most from less than full employment, and shortages of goods.

Looking specifically at the effects of higher prices in the cases reviewed above, lower-income groups probably benefited most from the increased supplies of electricity and water, whereas the effects of the prices of coal briquets and telephones are more questionable. It is not realistic to think that these or other goods and services are going to be more accessible to lower-income groups just because their prices are lower. As long as there is a scarcity demand, higher-income groups are going to satisfy their demands, even if it means paying black market prices for telephone service, for coal briquets,

or whatever is in short supply. The increased capacity of the electric company, for example, has done more than price subsidy schemes or any other measures could possibly have done to provide electric power as well as jobs to lower-income groups. The five-fold increase in generating capacity between 1962 and 1970 could not have occurred without electricity price increases unless other investment had been cut back and economic growth slowed, and the expansion of capacity has been accompanied by a halving of the constant-price costs of production and electricity prices. Lower than opportunity cost telephone prices have not helped lower-income groups, since the result has been a black-market cost far above the official price. Low briquet prices have meant a lower quality product and therefore more expensive heating, even without taking account of higher than controlled prices.

These strong conclusions about price policy for these products do not necessarily mean that the pricing policies in question could not have been improved upon, as has been noted. What it does mean is that increasing prices to more nearly their competitive market equilibrium levels, and therefore covering at least a substantial part of their opportunity cost of production, has been very beneficial to growth and to consumer welfare.

[ Extracted from Chapter 4 of  
Korean Pricing Policies and  
Economic Development in the  
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## Rice Price Policy in the Philippines

Leon A. Mears and Teresa L. Anden

[ Many governments undertake to control the price of their basic food staple, such as rice in the Philippines, in an effort to encourage producers and simultaneously protect consumers. This article describes the complex requirements that must be met for successful application of such a policy under Philippine conditions. ]

Over the past 20 years the Philippine Government has been actively engaged in programs to support a floor and control a ceiling price for palay (unmilled rice) and rice (milled). Under the 1966 law, rice producers were guaranteed a floor price of not less than P16 per cavan of palay and consumers a price ceiling not greater than P1.40 per ganta of rice, but these prices became unrealistic with the imposition of the floating exchange rate in 1970. (The ganta is about two kilograms; the cavan equals 44 kilos of palay or 56 kilos of milled rice. Current value of the Philippine Peso: 7P = US\$1.) The rice price spiral that followed in 1970/71 is only the most recent evidence of the continuing desirability for implementing the price stabilization function by an appropriate agency of the government. Other economic reasons include: 1) the large annual price fluctuations, far exceeding holding costs, that have occurred frequently at both farm and retail levels, 2) the evidence of several persistent inter-regional disequilibria in excess of transport costs, and 3) the emphasis by rice millers on trading profits at the expense of efficient management of processing activities. Further, there is overwhelming

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evidence that existing legal guidelines have lacked sufficient flexibility to permit effective implementation under continually changing conditions. They also have not sufficiently delineated general policy objectives to guide administrators toward synchronization with other development objectives and corrective action where market performance is inefficient.

Elements of a rice price policy. In its simplest effective form, rice price policy must satisfy the following Government objectives: 1) provide a price stability of this basic staple in line with the needs of uninterrupted development; 2) support a floor price that will appropriately stimulate production; 3) control a ceiling price that will assure rice at reasonable prices for consumers; 4) permit a seasonal range between these two prices to cover costs of holding stocks between harvests (including a premium for risk); 5) provide suitable relationships with other domestic and world prices; and 6) minimize Government implementation costs, taking into account the social and other Government objectives.

In terms of marketing efficiency these policies imply: 1) seasonal price increases commensurate with holding costs, 2) inter-market price differentials commensurate with transport costs, 3) processing costs commensurate with those possible with effective management, 4) a marketing system conducive to the introduction of cost reducing technology, and 5) domestic/world price relationships commensurate with the degree of self-sufficiency and the consequent export or import imperatives.

To satisfy these criteria will require strict financial and managerial discipline. However, similar policy objectives have been successfully implemented in other countries in Asia where the development was less advanced than in the Philippines. The only precaution would be to ensure that the specifics of the policy were realistic to the Philippine situation. They should take into consideration constraints relating to transportation, weather, processing, storage, cultural characteristics and organizational and financial capacities. These are discussed along with suggested procedures for determining relative prices within the policy guidelines.

Determination of price levels. Price determination can appropriately begin with the establishment of a floor price at bodegas (government buying centers) that will bring forth the desired production response. Determination of this price level should take into account the effects on hectarage planted in rice (and on yield), and on the use of modern yield-increasing inputs, of a change in the palay price relative to other prices. Studies of the price elasticity of hectarage planted by Dr. Mahar Mangahas can provide guidelines concerning hectarage and also the resulting yield changes,

but subjective evaluation must be relied upon to judge the effect of expected palay prices on increased input use.

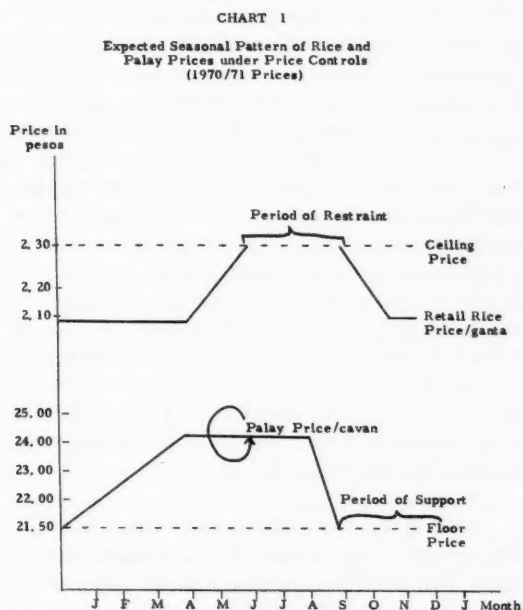
With the price structure of palay relative to other goods that existed in the late 1960s, together with credit provision and other support to farmers through the rice intensification program of the National Food and Agricultural Council (NFAC), increased input use was induced with resulting increased yields. Total output appears to have been close to the self-sufficiency level in 1970. So, a floor price at harvest that would at least maintain for the 1971/72 harvest the late 1960s terms of trade for the farmer would appear to be an appropriate first approximation. A first approximation for such a floor price for the Central Luzon region would approximate P21.50 per cavan of palay ordinario in 1971. (If inflation persists, further adjustments would be required.) This price should be announced several months ahead of each major planting season and maintained through the related harvest if it is to have the desired effect.

The time may be approaching when the guaranteed floor price can be reduced relative to other goods. The profitability of modern technology with improved seed is by now widely recognized in the Philippines. At 1971 fertilizer prices and a palay price of P21.50/cavan, expected incremental benefit/cost ratios are in the order of 3 to 1 for incremental fertilizer application of up to 90 kg. nitrogen/ha. (compared to no fertilizer use). Such ratios far exceed those necessary to attract and hold farmers with assured water supply to high-yielding seed and the modern inputs required. When the self-sufficiency objective is realized, the higher income generated by this technology can be transferred to other investment to the extent the floor price can be lowered and still induce production at a level to balance demand at the related ceiling price. To continue unnecessarily high price supports would tend to discourage the spread of modernization to a diversified agriculture. It also would perpetuate — without reason — the regressive income effects arising with the affluent farmer being more apt to have the irrigation which provides greater probability of realizing larger benefits from the new technology.

Given the historical average marketing margin in the Central Luzon/Manila market between 1958 and 1969 of approximately 25 percent from farm to retail, this floor price would lead to a retail price in Manila at harvest time of P2.08/ganta of "Macan" 2nd class rice. The retail price later in the year must be sufficiently higher than the harvest-time price to allow for costs and risk of holding for 4 to 5 months. This would require a 10 percent rise, or a ceiling price before harvest of approximately P2.30/ganta. It is important that this range allow for full storage costs as otherwise Government operation will have to displace private storage, with responsibilities and financing that the Government is probably not desirous of assuming.

As production nears self-sufficiency in the Philippines, this retail price seasonal range should include the world price to enable importation or exportation as may be required with greatest overall advantage. The center of the range indicated above would correspond to an FOB Manila price of approximately US\$145/ton on ordinary quality rice, 35 percent broken. This is almost double the 1971 export price for equivalent quality from either Thailand or Burma. The suggested price level therefore would prove profitable only for imports but would require a heavy subsidy for exports. This potential profit from imports explains why continued isolation of the domestic from the world market is necessary; unprogrammed imports by the private sector could interfere seriously with floor price maintenance. Uncertainty both as to production response and world price levels gives emphasis to the need for flexibility in legal price policy directives.

The seasonal pattern of retail rice and farm palay prices that might be expected in the Central Luzon/Manila region when maintaining the above floor and ceiling price limits is illustrated in Chart 1. The agency administering this policy for the Government would be expected to purchase at the floor price all quantities of palay offered at that price by the farmers and to inject rice in markets of major urban areas as required to keep the retail price below the ceiling.



Source: Basic Price Data: Farm prices, DANR, Bureau of Agricultural Economics; Rice prices, Bureau of Commerce, Manila.

Spatial price dimensions. The retail ceiling price level at major rice marketing and population centers outside Manila should correspond closely to the Manila ceiling if equilibrium is to be established through the market by private traders and speculators. Inter-market price ceiling differentials should not exceed transport costs. Deficit regions are an example where ceiling prices might exceed that in Manila but within transport cost limits.

Small regional differences will appear seasonally reflecting varying harvest patterns. This does not require differences in control prices interregionally. It means that seasonal support and injection periods will tend to differ, a consideration sometimes forgotten by head office administrators who are often caught by surprise when price fluctuates in regional centers.

Varietal standards. Two questions arise relative to rice varieties. Should different floor and ceiling prices be specified for key varieties or, if only one set of floor and ceiling prices is used, to what variety should it apply? Historical experience has demonstrated that commonly consumed varieties maintain price differentials that change but little over time. Thus, it can be expected that maintenance of floor and ceiling prices for one popular variety will set the relative price pattern of other varieties.

Selection of the standard variety depends on price policy objectives and market considerations. Considering the usual objective of assuring a reasonable price for the poorer consumer, most countries have chosen to support the floor price of an inexpensive common variety of palay. This tends to minimize subsidy requirements for stocks purchased at support levels and injected at the ceiling price. In the Philippines, this would mean a floor price for palay ordinario, a category which will include different varieties from region to region and over time, especially considering the rapid adoption taking place of new high yielding varieties. The ceiling price, then, must apply to common inexpensive varieties, with a second class milling that permits larger conversion and thus lower price. Some countries in Asia have attempted to support improved qualities as well as the cheaper ones. Given political and social realities in developing countries, such a policy has invariably increased stabilization costs. Government buying depots tend to classify most receipts at the higher price level, but political pressure requires that all stocks be sold at the ceiling price of the common varieties. To support only a higher quality variety leads to the same pitfalls.

The buffer stock. The price policy described above requires a buffer stock carefully spread out around the country to enable expeditious market injections for ceiling price maintenance. Such stocks are replenished by rice imports when floor price support does not

warrant palay purchases of the total required for the next season's buffer. Optimally, the size of the buffer stock will vary seasonally, with injections reducing stocks to a minimum prior to harvest and a maximum some months after harvest.

Subsidies to the NGA (National Grain Authority, which procures rice) can prove a heavy drain on Government revenues to the extent ceiling prices are set too low for recovery of storage and financing costs. Since these costs will vary depending on the degree of stability provided, serious consideration will need to be given to this decision. The buffer stock required to maintain a given ceiling price depends on the amount that annual production deviates from trend, with provision for additional stocks to allow for transport constraints and variable stock dispersion requirements. One standard deviation from the production trend approximates 90,000 tons of rice. In other words, with an allowance of a 10 percent increase for stock dispersion, it could be expected that a minimum buffer of about 100,000 rons of rice (3.4 million cavans of palay) would prove adequate to offset below-trend production and support the ceiling price in two-thirds of the years. A buffer of 200,000 tons of rice (6.8 million cavans of palay) would be expected to be adequate 95 percent of the time. This second alternative is the balance of risk against costs frequently chosen in other Asian countries. At mid-1971 prices, this represents an investment in palay of P150 million with holding costs over a normal year of approximately P15 million.

Management of buffer stocks would then anticipate a decline in stocks before harvest one year in twenty to as low as 20,000 tons. Handling of imports and exports would depend on crop reports early in the year. With poor crops and small buffer carry-over, imports need to be planned for arrival by mid-year. When forecasts indicate bumper crops, surplus for export may be predicted soon after harvest. Whether to hold large surpluses or export depends on relative costs. If exports are resorted to soon after an initial harvest, with adverse weather or disease reducing a later harvest, sufficient time remains to arrange for imports - which may bring a foreign exchange gain if low quality rice is imported to replace higher quality exported earlier.

Implementation and cost considerations. The above recognizes that the NGA cannot in a normal year cover costs of holding its base buffer stock without some subsidy, although the subsidy involved could be reduced by careful stock management. For example, a theoretical study by Shlomo Reutlinger suggests that budgetary costs might be reduced and social benefits increased by maintaining a smaller domestic buffer stock supplemented by more frequent imports and exports. It also is unlikely that the 10 percent seasonal

support spread will be sufficient to cover their costs on domestic palay bought and sold.

The subsidy necessary to cover these costs could be partially eliminated by widening the seasonal price spread through raising the ceiling price. While this would conserve Government revenues and benefit the taxpayer, the rice consumer would tend to suffer through higher prices, with the middlemen sharing in the benefits. It is unlikely that much of any benefit would be passed on to the producer. For each 100,000 tons sold by the Government at a 5 percent higher ceiling price, budget savings would approximate P4 million. The effect on the Consumer Price Index would be an increase of less than one-half of one percent.

Finally, there are details of policy implementation critical to success. As described above, the decisions to buy palay or inject rice are determined by market price alone. During critical seasons, management requires daily price quotations of controlled varieties, more specific than the quotations currently being supplied by the Bureau of Agricultural Economics. Decentralized authority for purchase and injection can reduce time lags in taking action. And, management must anticipate the requirements for dispersion of credit facilities in advance of harvest. For appropriate dispersal of buffer stocks, management must have frequent stock reports. Inter-regional shipments will be required at times. Also, firm arrangements must be made for milling palay so that rice will be available when needed. As there are limits to the time that rice or palay stocks can be held without excessive deterioration, arrangements are required for economically replacing old with new stocks when necessary.

[ Reprinted in Rice Economy of The Philippines, by Leon Mears, Meliza Agabin, Teresa Anden and Rosalinda Mauquez, pp. 217-224. Quezon City: University of the Philippines Press, 1974. ]

## Fertilizer Subsidies

Dana Dalrymple

[ Subsidies intended to stimulate the use of fertilizer by farmers are relatively common in developing countries, and appear to be increasing. But they can become very costly, especially since the 1974 rise in fertilizer prices; they present administrative problems; and their effectiveness in producing the desired result may be questioned. The available evidence on these matters is summarized. ]

The major purpose of subsidies has been to encourage farmers to use fertilizer and thereby expand agricultural production. Since chemical fertilizer is new to many of the farmers in the developing world, a subsidy might be aimed at the innovators and early adopters by lowering its cost. There may be a greater economic need to use a subsidy in the less developed countries (LDCs) than in developed countries because LDC fertilizer prices are often quite a bit higher while product prices may be lower. The recent sharp rise in world market fertilizer prices may lead to a second and relatively new reason for using subsidies: to help maintain existing fertilizer use in cases where product prices have not increased correspondingly. There has been some concern that the higher fertilizer prices will mean a reduction in demand for fertilizer and lower use on key crops.

Other reasons for subsidies are more mixed. It has been suggested, on the assumption that fertilizer production exhibits economies of scale, that subsidies may help expand the total domestic market for fertilizers and make the establishment of fertilizer manufacturing and distribution facilities economical. In

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other cases fertilizer subsidies may be just part of a package to increase food production: in Korea and Bangladesh, for example, fertilizer is part of a program of input subsidies which also includes other farm chemicals, credit, and seeds. In virtually all of these instances, the unstated assumption is that the subsidy is a temporary measure and that it would eventually be withdrawn.

Direct subsidies involve a government payment to some group in the fertilizer production and marketing chain. The major groups are manufacturers, importers, transport firms, distributors (including cooperatives), and farmers. The latter two groups appear to be the most prevalent targets for subsidy (see Table 1).

Table 1. POINTS OF APPLICATION OF FERTILIZER SUBSIDIES  
(numbers of cases)

<u>Surveys and Dates:</u>	<u>OECD</u> <u>(1968)</u>	<u>FAO</u> <u>(1974)</u>	<u>FAO/FLAC</u> <u>(1975)</u>
<u>Type of Recipient</u>			
Fertilizer manufacturers	1	6	10
Importers	1	1	4
Internal transporters	3	3	6
Distributors (inc. coops)	3	5	14
Farmers	9	22	7
Unidentified	0	0	11
Total cases *	17	37	52
Number of countries*	17	35	43

\*There are more cases than countries because some countries subsidize more than one type of recipient.

Indirect Subsidies. Many of the indirect forms of government assistance may be difficult to classify as subsidies. Others are more obvious. One of the more common is a fertilizer transport subsidy, which can take the form of a subsidy on costs to remote areas. In some cases, credit has been available at concessional terms (in the case of Brazil in the 1960s the interest rates on fertilizer loans varied from 0 to 7% while the rate of inflation went as high as 30%). In Argentina, a double tax writeoff has been allowed farmers on their fertilizer costs; other forms of tax concessions have been used in Chile. In the 1950s Brazil used a package involving a favorable exchange rate for fertilizer imports, tariff exemptions, state and federal tax exemptions, and highly preferential rail freight rates and port fees.

But perhaps the most important form of indirect help, which many might not put in the subsidy category, is the set of fertilization services which can be provided by the government extension service.

#### Frequency and Size of Direct Subsidies

Direct subsidies are fairly common among the LDCs and have been increasing since 1968. They have been most prevalent in Africa, followed by Asia. FAO and other data for the late 1960s and for early 1970s provide the following breakdown:

<u>Region</u>	<u>Number of Countries</u>	<u>Country</u>
Africa	20	Cameroon, Botswana, Dahomey Ethiopia, Gambia, Ghana, Ivory Coast, Kenya, Lesotho, Libya, Madagascar, Malawi, Mali, Nigeria, Senegal, Sierra Leone, Tunisia, Uganda, Upper Volta, Zambia.
Asia	12	Afghanistan, Bangladesh, India, Indonesia, Iran, Khmer Rep., South Korea, Nepal, Pakistan, Philippines, South Vietnam, Sri Lanka.
Latin America	3	Chile, Jamaica, Uruguay
Total	35	

A more recent FAO tabulation, noted above, suggests that in 1974 more than 43 developing countries had fertilizer subsidy programs. In view of the fertilizer price rise, the list may have lengthened still more in 1975 (Tanzania, for one, was added).

The size of the subsidies varies enormously. Most subsidies fall into the range of 10 to 50% of the farm gate price. It is difficult to make ready and precise comparisons because the subsidies apply at different points and vary by individual types of fertilizer. Some fertilizers are only subsidized if their price rises over a certain base figure. One summarization, based on fairly well standardized and comprehensive FAO tabulations, is available for 28 countries (Table 2). In some countries (Cameroon, Libya, Sri Lanka, and Uganda) the percentage is a constant amount, while in others the proportion varies by type of fertilizer — in some cases rather widely (in Mali the range was from a low of 13.9% to a high of 35.7%, and in Pakistan the range was from 13.6% to 54.5%).

Table 2. RATE OF FERTILIZER SUBSIDY IN THE DEVELOPING COUNTRIES  
1968/69 - 1971/72

(Percent of Unsubsidized Retail Price)

	Nitrogenous			Phosphate		Potash	
	Ammonium Sulphate	Ammonium Nitrate	Urea	Single S.P.	Triple S.P.	Potassium Sulfate	Muriate of Potash
Bangladesh	50.0		56.3		55.1		64.5
Botswana				28.7			
Cameroon 1/	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Chile	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Gambia				23.8			
Ghana	37.4			38.4		35.6	28.0
India 2/ 25-50%							
Ivory Coast 3/	33.0	33.0	33.0	33.0	33.0	33.0	33.0
Kenya				23.6			
Khmer	34.0		34.0			34.0	34.0
Lesotho	11.0		11.8	23.7			
Libya	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Madagascar	0.6		5.6				24.8
Mali	35.7		14.9	20.0	13.9		30.2
Nigeria 4/							
Pakistan	54.4	23.2	29.5	56.2	31.0	31.0	13.6
Senegal	47.8		47.6		45.6	27.4	
Sierra Leone	29.8			39.9			
Sri Lanka	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Tunisia	18.2	17.9	20.0				
Uganda	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Uruguay	19.7		81.4	35.3			
Zambia	33.6	33.9	54.6	29.3	28.2	41.4	51.4

Notes:

- 1/ 10% on all fertilizers used for cotton and coffee.  
2/ 25 to 50% on all fertilizers depending on the region.  
3/ 33% for cocoa, coffee and rice crops.  
4/ About 50% of the state store price on all fertilizers.

Source:

"Note on Fertilizer Subsidies", FAO, 1974, Table 1.

### Problems in Subsidy Programs

Management problems. Given a subsidy program, the administrators are apt to face at least two major problems: reaching the intended recipient, and establishing the appropriate subsidy level. The establishment of a subsidy does not automatically mean that it will benefit the group for whom it was intended. Since the subsidy can represent a

sizeable source of income many people would like to profit from it, and the benefits to the intended recipient may be substantially reduced. Two striking examples recently occurred in Asia. In South Vietnam, subsidized fertilizer was sold through authorized wholesalers and retailers at official prices. However, a South Vietnamese Senate Committee reportedly found that up to 70% of the fertilizer got into outside hands at one time, and was hoarded to force the price up. Farmers were often forced to pay double or more the subsidized official price. Merchants have reportedly been major beneficiaries of the subsidy program in Bangladesh intended for farmers. In both cases there are stories of smuggling to, respectively, North Vietnam and India.

Even if the fertilizer subsidy does reach the farmer, there is the problem, common to many government programs in agriculture around the world, that some farmers may benefit more than others. In Bangladesh, for instance, there is concern that it is the more economically and politically influential farmers who reap the most benefit from the subsidies. It has been suggested, therefore, that the removal of the subsidies would "neither dampen fertilizer demand significantly nor cause undue hardship to the poorer farmers." Whether such a statement would be true of other countries is unclear; there may be some where subsidies are very important to poorer farmers.

Another major management problem is the establishment of the proper subsidy level. If the subsidy is too low, it may not accomplish its intended purpose of encouraging farmers to take up or maintain fertilizer use. If the subsidy is too high it may lead to wasteful resource allocation. In either case, fertilizer use may be more profitable on some crops than others — and these may not be the ones for which it was intended. By definition, a subsidy means that the official price of fertilizer is less than it would be otherwise. This differential is apt to lead to the establishment of a black market. The black market, in turn, may thwart the original purpose of the subsidy.

Just how the subsidy level is actually established in most LDCs is, at this point, a matter of some mystery. It would appear, however, that in at least some countries there is an effort to strike a balance between official fertilizer and product prices. Indonesia and South Vietnam have for several years adjusted one or both prices to keep the fertilizer-rice price ratio in a certain range; in Vietnam the subsidy was designed to maintain a 2 to 1 ratio between the price paid by the farmers for a kilo of fertilizer and the price received by farmers for a kilo of paddy rice. In other cases, as fertilizer prices have shot up, the subsidy level may have been set at a level which would maintain an earlier level of farmer purchasing power.

In some cases the subsidy has been restricted to certain crops, or a differential pricing system has been established. In Sri Lanka, for instance, the subsidy was restricted to rice, tea and coconut farmers; but other farmers reportedly repurchased the subsidized fertilizer from these farmers at a price below the unsubsidized rate but still at a high enough price to provide a substantial profit to the rice and coconut growers. Hence "it is believed that a substantial proportion of the fertilizer supplied at subsidized rates to rice growers is not finally applied on rice land." In the Philippines, the fertilizer price for export crops has been roughly twice as high as for the subsidized price for rice. Enforcement is attempted by making fertilizer intended for rice available through a series of procurement vouchers. There are several reports of fertilizer being black-marketed and moved from one crop to another.

All of this may not be entirely undesirable in that most of the fertilizer probably eventually reaches those farmers with the greatest effective demand. However, small or poor farmers with potentially high response rates but with limited purchasing power or market access may lose out in the process. Hence, the result of the subsidy program may be quite different from what the governments wanted and/or the public was promised.

Financial problems. Subsidy programs for fertilizer can be very expensive for the modest agricultural budgets of many LDCs. One of the earlier programs, in Chile, was discontinued several times due to lack of funds. In Uruguay from 1961 to 1966, the annual cost of a relatively modest subsidization program was \$2.53 million and the government "from time to time" had difficulty in meeting payments. The cost in countries with more extensive subsidy programs is substantial: in South Korea the fertilizer subsidy cost \$8.84 million in 1968 and \$17 million in 1969; the expected cost of the fertilizer subsidy program in Afghanistan in 1975 is \$15.1 million; while in Bangladesh the proposed subsidy in the Five Year Plan totals \$50 million.

Where governments have tried to maintain relatively constant prices to the farmer in the face of increasing costs due to the 1974 rise in world prices, the budget burden can be immense. In Sri Lanka the subsidy was discontinued in 1974 because, in part, "the rising cost of the subsidy had become an excessive burden on the GSL budget." Indonesia has found that the cost of its fertilizer program could go from Rp. 2.54 billion (\$6.1 million) in 1971 to Rp. 30.0 billion (\$71.9 million) in 1973/74, nearly a twelvefold increase. This is viewed as "A burden which would clearly pose very serious financial problems for the country." Had India continued subsidizing fertilizer at previous levels in 1974/75 the cost would have been about \$500 million, "an amount which the government can ill afford to bear." The cost of the fertilizer subsidy program in Iran increased from some \$22.5 million a year

during the 1968/72 period to about \$113.5 million a year in 1974.

Clearly, subsidies may have profound financial cost implications for developing nations. And while the precise cost of subsidies is not predictable, neither are the benefits. There does not seem to be a great deal of evidence available to demonstrate the effectiveness of these vast expenditures in stimulating fertilizer use. This absence has been noted in at least several nations: Brazil, Jamaica, Kenya, and Tunisia. This is not to say that subsidies have been ineffective, only that remarkably little evidence seems to be available considering the substantial funds which have been involved. FAO has begun some studies in this area.

Withdrawing or reducing subsidies. Even if subsidies are established to encourage initial adoption, there is the problem, previously noted, of reducing or withdrawing the subsidy when the initial purpose is served. This may be particularly difficult with the recent fertilizer price hikes. Bangladesh provides a recent example of the difficulties in lowering a subsidy. As noted earlier, a substantial subsidy was set on fertilizer which turned out to be very expensive, ineffective, and possibly counter-productive. Accordingly, the government began to eliminate the subsidies on a phased basis over a five year period. While the phase-out may have been criticized by some as being too slow, it turned out to be too fast for various vested interests (including large farmers) and consequently ran into stiff political opposition in Parliament in June 1973. Consequently the reduction is being "delayed somewhat."

It may be naive to think that one can get around such problems very easily, but perhaps they would be ameliorated somewhat if their temporary nature were made known at the outset and a gradual phase-out schedule adopted and publicized. For instance, a subsidy for fertilizer on coffee in the Cameroon was scheduled to be phased out from 75% to zero over four years.

### Fertilizer Economics

Relatively little seems to be known with certainty of fertilizer economics at the farm level in the LDCs. Yet such information is of vital importance in designing and operating an effective and efficient subsidy program. We will briefly review some of the fragments of information which have been found concerning fertilizer prices, demand, and uses.

Profitability of fertilizer. There are great differences among countries in the prices paid for fertilizer, in the prices received for crops on which it may be used, and consequently in the relations between these prices which determine its profitability to farmers.

In the Indicative World Plan, FAO calculated some benefit-cost ratios which indicate the value of additional output resulting from fertilizer use divided by the cost of fertilizer; the higher the ratio, the more favorable the price conditions for fertilizer use. Generalized ratios were estimated for three regions in 1962 and then projected to 1975 and 1985.

<u>Region</u>	<u>1962</u>	<u>Projected 1975</u>	<u>Projected 1985</u>
South America	2.9	1.9	1.7
Africa (S. of Sahara)	4.4	3.3	3.7
Asia & Far East	4.7	4.5	4.5

The ratios appeared most favorable in Asia and the Far East and least favorable in South America. FAO stated: "Widespread experience suggests that benefit/cost ratios for fertilizers below 2.0 or 2.5 are usually insufficient to create a strong impetus for rapid increases in use." Latin America was projected to fall below these levels. [Note: considerable data on price ratios in particular countries were omitted from this excerpt.]

In view of the current fertilizer price situation, it would be important to know how these ratios have changed; the prices of farm products, of course, have also been changing. FAO has recently compiled some benefit-cost ratios for before and after the recent fertilizer price increases (although the precise dates varied, they were generally considered to be 1973 and 1974 respectively). Of 12 cases, from 10 countries, the ratio declined in 9 and increased in 2; in one case the result depended on whether farmers were able to get fertilizer at government controlled prices. When the data were further broken down by individual crops, out of 54 entries the ratio declined in 41, remained the same in one, and rose in 12. Still, the number of crop cases for which the ratio dropped below 2.0 increased only from 7 to 17; of the latter, 10 were in countries where free market prices existed and 7 where government controlled prices were the rule. Thus for most crops in most areas, fertilizer use continued to be profitable in terms of the FAO guidelines.

These, however, are only a partial measure. They may, in fact, not be highly correlated with profitability of fertilizer use. Data compiled by the International Potash Institute for six countries in 1972 and 1974 indicate that while the ratio declined in five countries, net returns remained the same or even increased. Similarly, FAO data show that even in some areas where ratios have declined moderately, such as in Java, net returns actually increased. Thus, it is

probably true, as OECD stated in 1968: "no general ratio between cost and return can be laid down as being necessary to promote fertilizer use in the developing countries as a whole." A number of other factors are involved.

Price elasticity of demand. As might be expected, the farm demand for fertilizer is inelastic in the short run and elastic in the longer run. On the basis of data from a number of studies summarized by Timmer in 1974, one could anticipate that: the immediate impact of a relative price reduction of 10% will be increased fertilizer consumption of anywhere from 5 to 10%; and in the longer run, if the same relative prices are maintained, the increase could be 2 to 3 times greater. Timmer is quick to add that in the longer run the same relative prices are not likely to be maintained.

The short and long term relationships noted here are in part based on the farmers' likely position on an S-shaped physical product curve for output responses to increasing use of fertilizer per acre: a little fertilizer produces small responses; increased fertilization brings a larger response; but above a certain level of fertilizer application the additional output tapers down. In areas of long-standing fertilizer use, farmers may have reached the upper level of the product curve where the marginal product declines. In areas where fertilizer use is more recent, farmers may be on the steeper part of the product curve. Thus, the newer adopters are more apt to get a larger response for a given input of fertilizer than the older adopters, and are therefore less sensitive to price fluctuations.

These figures, based on aggregate price responses of all farmers, do not clearly identify the responses of the small minority of new adopters at any given time. It is these farmers to whom subsidies should be directed; and their price responses might be reasonably elastic if they were found at the lowest portion of the marginal product curve. If the prospective adopters are generally poor farmers, price differences might be quite important to them. All this is difficult to measure with the price response data available. But it seems likely that high prices for fertilizer will, as Timmer put it, "hit the poor farmers and nations with high physical response rates relatively harder" than the wealthier farmers or nations.

Non-price factors influencing demand. Aside from the income level of the farmer, other general constraints are imposed by his related ability to carry, and his attitude toward, risk. Chemical fertilizers represent an additional expense in the production process. Should the rains not come, irrigation water be short, or some other natural calamity befall the farmer, he might not recover his investment. A related factor is the type of tenancy arrangement involved. For example, when a typical tenancy arrangement forces the farmer to pay for all inputs and deliver half the crop to the landlord, the

tenant who uses fertilizer loses half the return on his investment. There is also a problem of insecurity of tenure which affects the willingness to take risks.

The farmer's ability to buy fertilizer in the first place may be limited by several factors. One is simply that fertilizer is often not available at the right time and place and in the right form. Distribution channels may not be adequate. In some countries only one nutrient is provided, whereas a blend of nutrients is needed. The availability of credit, or its availability at a reasonable interest rate, is a commonly noted restraint for smaller farmers who do not normally have cash to buy fertilizer during the growing season. Another problem is lack of knowledge: many farmers simply do not have enough information about the value of fertilizer or about how to use it profitably. The availability of irrigation water may also be a significant restraint on fertilizer use, since it affects fertilizer responses. Where non-price factors of these kinds are important, they will greatly limit the numbers of farmers who are likely to adopt fertilizer use as the result of a low subsidized price.

One of the major factors influencing the use of fertilizer is the effectiveness with which it is utilized by particular plants. The fertilizer-responsive wheat and rice varieties that have constituted the backbone of the "Green Revolution" are ample proof of the value of such innovations. They raise the response curve for fertilizer; a given quantity of fertilizer will generally lead to greater levels of crop production with the high-yielding varieties than with traditional varieties. The gap widens at higher levels of application. Because of the presently low levels of use on food crops in LDCs a considerable technical potential exists. Further improvements in plant types and other technologies are likely to be developed. This prospect could be seen as a reason for promoting the habit of using fertilizer by all available means including subsidy — even if the latter is relatively inefficient.

#### Policy Implications

It is difficult to draw firm policy conclusions about subsidies for fertilizers in developing nations. The types of subsidies and range of conditions are too diverse for easy generalization. Still, some comments are possible. These should be prefaced with the acknowledgment that while I had a fairly open mind about fertilizer subsidies when I began this review, I am now considerably more skeptical about them.

The traditional argument for subsidies in LDCs has been to encourage fertilizer use. There may well be justification for temporary use of subsidies at the very earliest stages of the adoption process —

if it has been determined that a lowered price will provide a significant boost to adoption. This, however, is a significant condition. It is more of a generally accepted nostrum than well-proven fact. Still, it could be true in some cases. And since relatively small numbers of farmers may be involved for only a year or so, the government cost theoretically would not be great. The problem comes if the government doesn't make it clear in advance that the subsidy is temporary and if it doesn't withdraw it quickly enough. As with any subsidy, political pressures can force its continuation long past its period of peak usefulness.

The burden carried by the subsidy process has become immeasurably greater with the recent rises in fertilizer prices. These not only make the introduction process more difficult (to the extent that fertilizer price is important), but can add significantly to the cost of production of the adopting farmer. The short-run problems may be particularly severe for small farmers with limited credit. Thus there may be some need for financial relief at the farm level if fertilizer application and crop output are not to drop off.

The question is, then, whether a fertilizer subsidy is the most efficient and appropriate vehicle. Subsidies can be very expensive in terms of limited LDC budgets and they do not necessarily insure that the fertilizer reaches its intended use. Increased prices of certain crops could help draw the fertilizer into that use. But to do this entirely by supporting the price of the crops could also be expensive. One alternative would be to simply allow increased fertilizer costs to be reflected in increased food prices. This would raise the incentive to apply fertilizer (though it would not guarantee its use) and the "taxing" would be done by the higher consumer prices. Since the lowest income groups in the cities and among farmers not producing food crops would suffer in this process, a food subsidy program might be used to keep nutrition levels from dropping. And additional credit may need to be provided to small farmers lest they be unduly disadvantaged. Such an alternative program may be unrealistic and open to criticism. It is idealized in that few politicians would carry it out in the face of increased complaints about the retail food prices. Also, the program might be considered inflationary. But the sad fact is that unless product prices at the farm level are allowed to rise, there will be little incentive for farmers to increase output.

More general government price subsidies could moderate the increase in crop prices to consumers, but there is always the danger that they might represent an even larger budgetary cost than fertilizer subsidies. This is not to say, however, that there isn't any place where price supports could be useful; a small program might well provide an initial incentive for fertilizer use on certain crops. And

if an extensive subsidy program is to be set up, both input and product prices may need to be wrapped up together. Most countries, however, will not be able to afford such a highly subsidized program for very long. Furthermore, there can be a substantial opportunity cost in devoting many resources to subsidy programs. To the extent that policy personnel are engaged in the many complexities of such programs, they may overlook or underfund other important longer-term ways of meeting the fertilizer problem which could lead to a more rationally-based program of fertilizer use on LDC farms in the future.

The problem, as always in the times of crisis, is to escape the present. I see no easy way out. Retail food prices in the LDCs are going to have to be allowed to rise to reflect the higher fertilizer cost. To do otherwise by resorting to extensive subsidies is not going to do the trick very long; it is simply too expensive in budget terms. And it does not lay the economic and technical base for continued production increases in the future.

Thus my own view is that subsidies should be used very cautiously and very selectively. There may be cases where they can help introduce fertilizer or be of needed assistance to small and/or poor farmers. And there may be instances where adjustments in product prices can help direct their use to certain crops. But on the whole I would tend to allow product prices to rise and, where time permits, turn my thinking and limited funding elsewhere — to the better identification of constraints on fertilizer use, to increasing the efficiency of fertilizer distribution and its use by plants. In short I would try to make the best possible utilization of what little fertilizer I had. This would, however, require much more knowledge about the fertilizer situation at the farm level than presently exists in most developing nations.

[ Extracted from Evaluating Fertilizer Subsidies in Developing Countries, AID Discussion Paper No. 30. Washington, D. C. : U. S. Agency for International Development, May 1975. ]





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